PROCEEDINGS

OF THE

IOWA ACADEMY OF SCIENCE

FOR 1906

VOLUME XIII

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES
B. MURPHY, STATE PRINTER
1906

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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, AUGUST 11, 1906.

To His Excellency, ALBERT B. CUMMINS, Governor of Iowa:

In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the twentieth annual session of the Iowa Academy of Science and request that you order the same to be printed.

Respectfully submitted.

L. S. ROSS,
Secretary Iowa Academy of Science.

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PROCEEDINGS

OF THE

TWENTIETH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The twentieth annual meeting of the Iowa Academy of Science was held in the rooms of the Department of Botany of the Iowa State College at Ames, April 20 and 21, 1906. In the business session the following matters of general interest were presented.

REPORT OF THE SECRETARY.

TO THE MEMBERS OF THE IOWA ACADEMY OF SCIENCE:

At the Nineteenth Annual Meeting of the Academy seven members were promoted to fellows and six new names were added to the list, making a total increase of thirteen to the number of fellows. At the same meeting three fellows were transferred to the list of corresponding members on account of their removal from the state. At present the membership of the Academy consists of sixty-eight fellows, sixty-six associate members and fifty-four corresponding members; making a total of one hundred and eighty-eight. So far as the secretary has learned, the ranks of the Academy have not been invaded by death since our meeting one year ago.

Notwithstanding the fact that our total membership numbers twenty-nine more than one year ago, there is still need of earnest, aggressive work to increase and enlarge the influence of the Academy membership.

The copy for volume XII of the Proceedings of the Iowa Academy of Science was put into the hands of the printer the latter part of June and the edition was received from the Bindery and distributed about the last of July. The present plan of arranging the papers that make up the Proceedings makes it possible for us to furnish 100 separates to the authors of the several articles at a very small cost to the Academy. The expense for 100 reprints of each paper in volume XII did not exceed $37.00. I would recommend that in the arrangement with the State Printer for the 100 extra copies for the Academy, a better grade of paper should be purchased than that used for the state work.

The State Printer has been eminently fair and obliging in connection with the Academy work, and I am glad to testify to the improvement in this regard since a few years ago.

The Executive Council very courteously allowed all the plates that were requested for the last voume of the Proceedings. However they especially requested that in the future there should be submitted with each drawing or photograph, from which a plate is to be made, a short description stating what such drawing or photograph represents, and the reason why it is desirable that the same should be used as an illustration in addition to the description of the same facts in the text. Since the members of the Executive Council are not scientists, and since the Secretary cannot have such a knowledge of every branch of science as to enable him to present the descriptions and claims for each illustration as well as can the party who submits the same, I think the request should be endorsed by the Academy.

In accordance with your suggestion at the Grinnell Meeting last year, there is presented below a list of the periodicals and books that have come to the Academy of Science library the past year in exchange for the Proceedings:

American Academy of Arts and Science, (Proceedings) Boston.

Augustana College Library, (Publications, Rock Island, Ill.)

Belgique-L'Observatoire Royal. Annals de Bruxelles, Smithsonian Exchanges.

Biological Society of Washington (Proceedings) Washington, D. C.

Boston Society of Natural History (Proceedings), Boston.

Brazil Para Museue Croeldi Publicavoea (do) Memorias, Para, Brazil.

Brooklyn Inst, of Arts & Sci. Museum Bulletin, Brooklyn, N. Y.

California Acad. Sci., (Memoirs) San Francisco, Cal.

California Acad. Sciences Occasional Papers, San Francisco, Cal.

California Acad. Sciences (Proceedings. Geology). San Francisco, Cal.

California Acad. Sciences (Proceedings Zoology) San Francisco, Cal.

Cincinnati Soc. of Nat. Hist., (Journal) Cincinnati, Ohio.

Colorado College Publications, Colorado Springs, Colo.

Colorado Scientific Society, (Proceedings) Denver, Colo.

Colorado University of, Studies, Boulder, Colo.

Cuepre de Ingenieros de Minas del Peru Boletin, Lima..

Denison University, Bulletin of Scientific Laboratories, Granville, O.

Edinburgh-Royal Society, Proceedings, Edinburgh. (Smithsonian Exchanges.)

Field Cclumbian Museum, Publications, Chicago, Ill.

Georgia State Board of Entomology, Bulletin, Atlanta, Ga.

Gray Herbarium of Harvard University, Proceedings, Cambridge, Mass.

Kansas University of, Science, Bulletin, Lawrence, Kan.

Mexico Observatorio Meterrologico Central de Boletin Mensual, Palacio Nacional, Mexico. (Smithsonian Exchanges).

Michigan Academy of Sciences, Report, Lansing, Mich.

Minnesota Academy of Natural Sciences, Bulletin, Minneapolis, Minn.

Montreal Natural Hist. Soc., Canadian Record of Science, Montreal.

Museum of Comparative Zoology, Harvard College, Bulletin, Cambridge.

Naturforsehenden Gesellschaft Milteilungen, Bern, (Smithsonian Exchanges.)

Naturforsehenden Gezellschaft Vierteljahrschrift, Zurich, (Smith-Exch.)

Nebraska University Studies, Lincoln, Nebraska.

New York Academy of Sciences, Annals, New York.

New York Botanical Garden, Bulletin.

Nova Scotian Institute of Science Proceedings & Transactions, Halifax, N. S.

Oberhessischen Gezellschaft Fur Natur und Heilkunde Breicht, Giesse (Smithsonian Exchanges).

Oberlin College Library, Wilson Bulletin, Oberlin, Ohio.

Ohio Arch. & Hist. Soc., Quarterly, Columbus, Ohio.

Ohio Geological Survey, Bulletin, Columbus, Ohio.

Ohio State Acad. of Sci., Proceedings, Columbus, Ohio.

Ohio State University Agricultural College, Extension Bulletin, Columbus, Ohio.

Ohio State University, Bulletin, Columbus, Ohio.

Philadelphia Academy of Natural Sciences, Proceedings, Philadelphia.

Philosophical So. of Washington, Bulletin, Washington, D. C.

Reåle Instituto Lombardo di Scienze e lettre, Rendiconte, Milano. (Smithsonian Exchanges).

Rochester Acad. of Sciences, Proceedings, Rochester, N. Y.

Rio de Janerio Museum Nacional (do) Archivos (do), Rio de Janerio.

St. Louis Acad. Sci., Transactions, Washington University, St. Louis, Mo.

Smithsonian Institute Bu. of America, Ethnology Bulletin, Washington, D. C.

Smithsonian Institution Am. Report, Washington, D. C.

Smithsonian Inst. Nat. Muse. Buletin, Washington, D. C.

Sociedade Scientifica Revista Sao Paulo, Brazil, S. A. (Smithsonian Institution Exchanges).

Staten Island Nat. Sci. Assn. Proceedings, New York.

Texas University of, Bulletin, Austin, Texas.

Tufts College Studies, Tufts College, Mass.

U. S. Bureau of Amer. Ethnology, Am. Report, Washington, D. C.

U. S. Department of Agriculture Monthly List of Publications, Washington.

U. S. Geological Survey, Bulletins, Washington, D. C.

U. S. Geological Survey, Mineral Resources, Washington, D. C.

U. S. Geological Survey, Monographs, Washington, D. C.

U. S. Geological Survey, Professional Papers, Washington, D. C.

U. S. Geological Survey, Water Supply Papers, Washington, D. C.

U. S. Interior Dept. of Ethnological Survey Publications, Washington.

U. S. National Museum, Proceedings, Washington, D. C.

Victoria Royal Society, Proceedings, Melbourne, Australia.

Wisconsin University Bulletin, Madison, Wisconsin.

Wyoming University of, Bulletin of School of Mines, Laramie, Wyoming.

Yale University Geol. Dept. Geol. Papers.

Zoologisch-botanischen Gezellschaft, Verhandlungen, Wein. (Smithsonian Exchanges).

Respectfully submitted,
T. E. SAVAGE, Secretary.

REPORT OF TREASURER FOR 1905-1906.

RECEIPTS.

Balance from 1904-1905		**$124.79**	
Dues and initiation fees		**141.08**	
Sale of Proceedings		**3.75**	
			$269.62

EXPENDITURES.

1905.			
May 3	**Express on Treasurer's book from H. W. Norris**	**.45**	
May 8	**50 2c stamps, Treasurer's use**	**1.00**	
Aug. 8	**Iowa Printing Co., 100 extra Annual Reports**	**16.00**	
	Howard Tedford, binding 200 copies in cloth $22.00		
	Stitching, etc., 100 sets separately, $15.00	**37.00**	
1906.			
Jan. 25	**Honorarium to Sec'y Savage**	**25.00**	
	Bishard Bros. 500 envelopes and 150 circulars	**3.50**	
	Secretary, postage, correspondence and proof of Proc. XII	**2.50**	
	Secretary, postage, circular for Ames meeting	3.00	
Apr. 20.	Bisnard Bros., programs	5.00	
	Secretary, postage	3.55	
			97.00
	Cash on hand...............		**$172.62**

REPORT OF THE COMMITTEE ON MEMBERSHIP.

The Committee on Membership recommended the following transfers and additions to the lists of Fellows and Associate Members, which recommendation was adopted by the Academy.

TRANSFERRED FROM ASSOCIATED MEMBER TO FELLOW.

F. W. Bouske, Ames; L. G. Michael, Ames.

ELECTED FELLOWS.

S. A. Beach, Ames; E. J. Cable, Cedar Falls; F. E. Guthe, Iowa City; C. Larson, Ames; D. W. Morehouse, Des Moines; B. A. Place, Indianola; H. J. Quayle, Ames; W. H. Stevenson, Ames; Frank A. Stromsten, Iowa City.

ELECTED ASSOCIATE MEMBERS.

John F. Arnold, Indianola; Floyd E. Bartell, Indianola; C. E. Bartholemew, Ames; F. A. Brown, East Peru; J. A. Coss, Fayette; C. H. Churchill, Fort Dodge; Carrie M. Greene, Fayette; Carl Fritz Henning, Boone; Leonard M. Liddle, Mt. Vernon; H. W. Moody, Ft. Dodge; Clarence E. Nickel, Des Moines; E. C. Place, Ames; F. L. Rainey, Fairfield; T. Roberts, St. Charles; M. P. Somes, Ft. Dodge; Blanch Stoddard, Iowa Falls; Forrest Wheeler, Fort Dodge; Ward H. Wheeler, Mt. Vernon.

Signed,
W. S. HENDRIXSON,
T. E. SAVAGE,
H. E. SUMMERS.

REPORT OF COMMITTEE ON RESOLUTIONS.

Resolved—First. That the Iowa Academy of Science assembled expresses its grateful appreciation of the hospitality extended by the citizens of Ames.

Resolved—Second: That the Academy recognize its indebtedness to the President and faculty of the Iowa State College of Agriculture and Mechanical Arts by whose efforts the local arrangements were perfected.

Resolved—Third: That we express our appreciation of the lectures delivered by Dr. Herman von Schrenk, Dr. C. R. Barnes and Dr. C. E. Bessey.

Resolved—Fourth: That the Secretary of the Iowa Academy of Science be instructed to send to each of the Congressmen from Iowa the expression of the earnest hope of the members of the Academy that, in the near future the Metric System of weights and measures will displace the so called English System now in common use; and our hope that the members of Congress from Iowa will vote for the bill now pending which provides that from and after the first of July, nineteen hundred and eight, all of the departments of the government of the United States, in the transaction of business requiring the use of weights and measurements, shall employ and use the weights and measures of the Metric System.

Resolved—Fifth: That we extend to the California Academy of Sciences our sympathy on account of the great loss in books and valuable documents they have recently sustained by earthquake and fire, also:

Whereas, Dr. C. E. Bessey of Nebraska University has been suggested by many of his friends for the vacant Secretaryship of the Smithsonian Institution, and

Whereas, his wide reputation as a ripe scholar, his great executive ability as well as his unusual alertness and activity of mind, qualify him especially for such a position:

Therefore the Iowa Academy of Science assembled at Ames, April 21, 1906, do heartily commend his candidacy and most respectfully urge upon the Trustees of the Institution the careful consideration of his qualifications. Committee,

C. O. BATES,
W. J. MEEK,
L. BEGEMAN.

The Committee on Secretary's report recommended that the suggestions made by the Secretary relative to providing a better quality of paper for the Authors Reprints, and requesting that there should be submitted with each drawing or photograph from which a plate for illustration is to be made, a description of the same and also the reason why it is desirable that the same should be used as an illustration in addition to the description of the facts, in the text (this latter is at the request of the Executive Council who authorizes the plates illustrating the Academy Proceedings to be made) be ordered by the Academy. The Committee also recommended that the Secretary should be given an honorarium of $25.00 for the ensuing year.

The Committee on Necrology reported that there had been no death in the Membership of the Academy during the past year.

OFFICERS FOR THE YEAR 1906-7.

President, C. O. Bates.

First Vice President, G. E. Finch.

Second Vice President, A. A. Bennett.

Secretary, L. S. Ross.

Treasurer, H. E. Summers.

Executive Committee, Ex-Officio, C. O. Bates, G. E. Finch, A. A. Bennett, L. S. Ross, H. E. Summers.

Elective, H. M. Kelly, F. F. Almy, C. F. Lorenz.

The following papers were presented before the Academy:

Presidential address, "A Review of the development of Mineralogy".—M. F. Arey.

"The Carotid Arteries and Their Relation to the Circle of Willis in the Cat."—H. W. Norris.

"A Study of Dolomite and Magnesite with Special Reference to the Separation of Calcium and Magnesium."—N. Knight.

"Ecological Notes from an Illinois Esker."—Bruce Fink.

"The Disparity Between Age and Development in the Human Family."—J. Fred Clark. (Illustrated by pronounced cases due to thyroid malformations.)

"Some Diseases of Rocky Mountain Plants."—L. H. Pammel.

"An Attempt to Illustrate Tides and Tidal Action."—John L. Tilton.

(a) "More Light on the Origin of the Missouri River Loess." (b) "Some Variant Conclusions in Iowa Geology."—J. E. Todd.

(a) "The Action of Bromic Acid on Metals." (b) "Logarithmic Factors for Use in Water Analysis." (c) "A List of Chemical Periodicals in Iowa."—W. S. Hendrixson.

"Liliaceae of Iowa."—T. J. Fitzpatrick.

"Mutual Induction and Internal Resistance of a Battery."—L. Begema.n

"Lichens and Recent Conceptions of Species."—Bruce Fink.

"Some Unusual Features of the Maquoketa Shale in Jackson county, Iowa."—T. E. Savage.

"A Study of the Choroid Plexus."—Walter J. Meek.

(a) "The Effect of Pressure on Lines in the Spectrum of Iron." (b) "A Simple Demonstration of the Doppler Effect in Sound." (c) "The Physical Laboratory at Iowa College."—Frank F. Almy.

"A Portion of the Iowan Drift Border in Fayette county, Iowa."—G. E. Finch.

"The Relation of the Motor Nerve Endings to Voluntary Muscle in Amphibia." —B. A. Place.

"Notes on the Discomycete Flora of Iowa."—Fred J. Seaver.

(a) "Lime Creek Fauna of Iowa in Southwestern United States and Northern Mexican Region." (b) "Geology of the Corinth Canal Zone." (c) "Alternation of Fossil Faunas."—Charles R. Keyes.

"The Collembolan Eye."—J. E. Guthrie.

"Flowering Plants of Calcasieu Parish, Louisiana."—J. M. Lindly.

"Some Controbutions to Madison county Geology."—F. A. Brown.

"Flora of Webster county, Iowa."—O. M. Oleson and M. P. Somes.

"Electrical Units."—K. E. Guthe.

"The Holding and Reclamation of Sand Dunes by Tree Planting."—H. P. Baker.

(a)" The Food of Subterranean Crustacea." (b) "Number of Bacteria in Des Moines School Buildings."—L. S. Ross.

"Cladocera in the Vicinity of Des Moines."—B. O. Gammon. Presented by L. S. Ross.

Photographic Accessories of Drake University Equatorial."—D. W. Morehouse. Introduced by L. S. Ross.

"Municipal Hygiene—Part II—Milk."—C. O. Bates.

"Cyclonic Distribution of Precipitation."—J. A. Udden.

Besides the regular papers presented by members of the Academy Dr. Hermann von Schrenk of the U. S. Dept. of Agriculture gave an address on Friday afternoon on the subject "Some Practical Applications of Scientific Research"; Dr. Chas. E. Barnes of the University of Chicago delievered a lecture before the Academy on Friday evening on the subject "How Plants Breathe". On Saturday morning Dr. Charles E. Bessey of the University of Nebraska presented a paper on the distribution of forest trees in Nebraska.

PRESIDENTIAL ADDRESS

A REVIEW OF THE DEVELOPMENT OF MINERALOGY.

BY MELVIN F. AREY.

Man's interest in and knowledge of some of the commoner minerals such as quartz, mica and calcite, the native metals and the precious stones, must have begun practically with the beginning of his occupancy of the earth and the command given to him to subdue the earth involved bringing its inorganic matters within the range of his knowledge and control. Thus early were the physical sciences authoritatively introduced into the curriculum of the great school of his life. The first note of progress is made early in Genesis in the mention of Tubal Cain as "an instructor of every artificer of brass and iron"; the gold, bdellium, whatever that may be, and the onyx stone are previously mentioned. The Pentateuch indicates a ready practical knowledge of a half dozen metals and as many more precious stones. Theophrastus, a Greek, who lived about three hundred years before Christ, has left the earliest specific writings upon minerals. The elder Pliny, with his wide embracing interest in every phase of natural history, did not neglect the minerals and made some interesting records of his observations upon them. Avicenna in the eleventh century, so far as is known, made the first attempt to classify minerals. His effort was necesarily crude and unsatisfactory. However, the number of minerals known and the knowledge of uses that could be made of them gradually increased thru the centuries. Among other causes the eager desire for gold, the belief that the baser might be transmuted into it, together with a universal hope that somehow a panacea for the ills of the body might be found, stimulated research and resulted in the acquirement of a working knowledge of the physical and chemical properties of many mineral substances.

There is little evidence that any well directed effort to make a systematic array of the facts and principles respecting inorganic substances had been made before the middle of the eighteenth century. The foundations of any science are well laid only after the tentative setting forth of a variety of theories, the earlier of which are crude often and in the light of later established principles, absurdly inadequate. So was it with mineralogy. Crystals by their natural beauty early attracted attention. At first the seemingly endless diversity of crystalline forms prevented the recognition of any connection between fixity of form and kind. Naturally the faces were considered in the first attempt to establish this fact and in consequence failure resulted. The inherent tendency of the mind to generalize and guess rather than to examine and measure, as Whewell

expresses it, led to various assumptions, the prevalence of which were serious obstacles to the initiation of any attempt to arrive at better conclusions. Thus Pliny, Gessner, in the sixteenth century, Caesalpinus in the seventeenth and even Buffon in the eighteenth, denied the fixity of form of crystals. Nicholas Steno in 1669 published the statement that tho the sides of the hexagonal crystal may vary the angles are not changed. This dictum, tho not accepted by all, as we have seen, became the basis of much patient observation on the part of many. Linnaeus first attempted to make the crystalline form the basis for the arrangement of minerals in groups, but was not successful in his plan. However, Rome 'de Lisle, in reading the works of Linnaeus, found suggestions that led to his giving to the form of crystals his devoted study thru a wide range of application. By his efforts and those of Hauy a little later, crystallography was definitely founded as a means of determining minerals apart from chemistry. The part of Rome 'de Lisle seems to have been to prepare the way by patient industry in investigation of details for the establishment by Hauy of the principles of crystallography upon such a sure foundation that they have been recognized and employed ever since by all those who have continued the work. To him is given the credit of maintaining the importance of cleavage and the consequent explanation of the derivation of secondary from primary forms by means of the decrements of the successive layers of integral molecules; "the mathematical deduction of the dimensions and proportions of these secondary forms; the invention of a notation to express them; the examination of the whole mineral kingdom in accordance with these views; and the production of a work in which they are explained with singular clearness and vivacity." His industry and skill command the admiration of all who have become acquainted with the contributions which he has made to the evolution of crystallography. Some of his devices and deductions have been superseded by the results of later investigations, but even they served a valuable purpose in becoming the vehicles for the safe carriage of facts which were necessary to the successful determination of the better systems of those who could thus profit by the labors of this truly remarkable pioneer in mineralogy. It is true that he had the results of the labors of the painstaking and enthusiastic Rome 'de Lisle and others by which to profit, but his, nevertheless, is the unique virtue of having used them in such a manner as to have wrought them into a consistent and acceptable system that in its essential features continues in force up to the present time.

Later progress in crystallography has consisted largely in increasing the accuracy of angle measurements and in adding to our knowledge of derived forms. Wollaston made the first of these more readily possible by his invention of the reflecting goniometer by which the angles of very minute faces could be measured with great accuracy. Two other Englishmen, Phillips and Brooke, made diligent use of this instrument in securing exact measurements of the angles of a large number of minerals, the results of which were published for the benefit of students of the science.

To Weiss and Mohs chiefly is due the credit of making the Axes of Symmetry the bases for the arrangement of crystalline forms into systems, which arrangement has been confirmed by the other properties of minerals that received attention at about the same time. Sir David Brewster, in his optical researches, discovered that double refraction pertained solely to crystals of the rhombohedral system. Later he found that all crystals of the pyramidal and rhombohedral systems which from their geometrical character have a single axis of symmetry are optically uniaxial, while the prismatic system which has three unequal axes of symmetry is optically biaxial and has three rectangular axes of unequal elasticity. While Brewster's discoveries and conclusions were reached independently of Weiss and Mohs, they cover very much the same ground, tho' reached by a very different path, and support the conclusions of the last named investigators in a remarkable manner. Later investigations along both lines have resulted in establishing a very high degree of correspondence between mathematical and optical symmetry and have given to crystallography an assured place of first class importance in mineralogy.

Hauy had assumed that the same chemical elements, combined in the same proportion, would always have the same crystalline form, and, consequently, the same form and angles implied the same chemical constitution. But there were continually arising very perplexing exceptions to this view. Fuchs was led to account for this on the principle that one element might take the place of another in some instances without altering the crystalline form. To such elements he applied the term vicarious. He is said afterward to have withdrawn from his position in this matter. But Mitscherlich, by many careful analyses, clearly established the fact that several substances such as "the carbonates of lime, of magnesia, of protoxide of iron and of protoxide of manganese agree in many respects of form, while the homologous angles vary thru one or two degrees only". These and similar substances were said to be isomorphous, if the agreement was complete, or exact; while the term plesiomorphic was given to such as varied slightly. This discovery resulted in stimulating great activity among chemists and crystallographers in the expectation of discovering definite laws pertaining to the relation between chemical composition and crystalline form. One result of such effort was the recognition of cases that seem to be exceptional and outside of the usual laws governing mineral form and composition, such as dimorphism and trimorphism, an illustration of the former of which we have in calcite and aragonite.

It will be seen from the discussion of the development of crystallography that the establishment of any satisfactory system has depended upon the agreement of fixity of form and angle with kind. While Hauy and his followers were unfolding the principles of crystallography and placing them upon a sure basis, Abraham Werner was laboring to find in the fixity of the other properties of minerals as certain a basis for a different system of classification and determination. Possessed of exact and methodical mental powers and great acuteness of the senses, he was eminently adapted to the founding of such a system. In this work he

relied mainly upon color, luster, hardness and specific gravity, all of which with practice are readily determinable, a very little apparatus of the simplest character being required. His success as a mineralogist attracted general attention at once and students from every part of Europe attended his lectures at Freiberg with the result that his method of employing external characters in the determination of minerals was promptly and widely disseminated. Mohs, his successor at Freiberg, improved Werner's standards and nomenclature, an illustration of which is found in the scale of hardness still in use with which the hardness of any mineral in question may be brought into comparison with ready exactness.

Every early investigator in mineralogy had felt the necessity for a complete system of classification and sought to discover some basis on which such a system could be devised. Thus chemistry, crystallography, and physical properties had been appealed to in turn for a key to some system by which a new specimen could be placed in its proper relations to those already fixed in the system and that would enable a student to find with certainty the name and place of any specimen that might fall into his hands, but each of these failed in some particulars to yield the desired result. Hence arose the mixed system of Werner, Hauy, Phillips and others, systems that still left much to be desired. Mohs the pupil and successor of Werner, earnestly believed that a natural system of mineralogy might be discovered as Linnaeus had done for botany. His intimate acquaintance with minerals, together with his ardor as a student of reform, enabled him to undertake such a work with as great a promise of success as could have fallen to any one, but the effort was too much for him.

The new nomenclature proposed by him, requiring as it did a complete change of names and terms previously used, overloaded a system which of itself failed to impress those interested in the subject with a confidence in its inherent worth. In like manner Berzelius made two distinct attempts to establish a system based purely on chemical principles, but his system never had the recognition he had looked for. The effort in each of the above cited instances, as well as in others of similar purpose and scope, while resulting in marked advancement in the status of the science, only made it more and more decidedly apparent that no system could meet with general acceptance that did not so combine chemical, crystallographic, optical and physical properties of minerals as to result in a fairly complete harmony and coincidence of the principles of each with those of the others.

It remained for the chemists and mineralogists of the last half of the eighteenth century to devote attention to a new question, the origin of minerals. In a review of the names of those who have secured eminence as contributors to the science of mineralogy, it will be noted that the majority of them are French or German in nationality. In like manner France and Germany have contributed to the solution of the question of the origin of minerals the greater part of effort and consequently have won the greater share of the honors.. It has required much patient devotion and skill to overcome the difficulties that thickly beset the

path of progress in this as in other directions, but the results are highly gratifying, both in themselves and in the light they have let in upon the problem of classification of minerals. The key to the origin of minerals has been found in their artificial reproduction, using similar agents and like conditions, as in nature. Not more than half a dozen minerals remain that have not been artificially reproduced, so successful has been the work.

One result of this line of investigation has been a better delimitation of mineral families, even new members having been added by this process. By synthesis it has been discovered that many minerals, especially those of metamorphic origin, are never pure in nature, their exact composition not having been known until they had been artificially reproduced.

Geology has profited by this work also. For example the origin of granite had long baffled the geologists, but synthesis conclusively proved that granite could not be formed by purely igneous fusion, thus confirming the theory that it was of mixed origin. What the future has in store for the science of mineralogy it is impossible even to conjecture, but it would seem that its foundations at least have been broadly and securely laid.

In the consideration of my subject thus far, attention has been directed exclusively to the work accomplished in Europe. We now turn briefly to mineralogy in America. Practically no effort was made in this country along this line during the eighteenth century. Professor Silliman says that in 1803 it was a matter of extreme difficulty to obtain among ourselves even the names of the most common stones and minerals; and one might inquire earnestly and long before he could find any one to identify even quartz, feldspar, or hornblende among the simple minerals, or granits, porphyry, or trap among the rocks. There were at this time no text books, cabinets of minerals, or apparatus to aid or stimulate the latent interest of the people in this subject. In 1798 in New York the beginning of effort along this line was made by the organization of the American Mineralogical Society, of which Dr. Samuel Lathan Mitchell was the first president and the most active member. From this time interest and activity in the kindred sciences of chemistry and mineralogy grew with characteristic American spirit and enterprise. Chairs were established in the colleges and steps were taken to have these sciences taught in the higher schools. As a result of this activity a catalog of American minerals with their localities was published in 1825 by Dr. Samuel Robinson. This catalog contained over three hundred pages. Among the early promoters of this science, four stand forth with marked prominence, Dr. Archibald Bruce, Colonel George Gibbs, Professor Parker Cleaveland and Professor Benjamin Silliman.

Dr. Bruce, by the exchange of American specimens and by travel in Europe, during which he made the acquaintance of Hauy and others eminent in the science, gathered together an extensive cabinet of choice minerals, which with another collection made by Mr. B. D. Perkins was made readily accessible to the general public. They proved a remarkable stimulus to the popular interest in mineralogy. Dr. Bruce also established the American Journal of Mineralogy, the first purely scientific

periodical in America. Tho of excellent character it met with the fate of many another worthy journalistic attempt thru lack of support. It may be stated here that Dr. Bruce gave in this journal a description of the Native Magnesia of Hoboken and of the Red Zinc Oxide of Sussex county, New Jersey, the first American species described by an American mineralogist. It is said that so well was his work done that these species remain today essentially as he described them, and that his papers are models of accuracy and form of statement.

Colonel Gibbs, a young man of considerable means, was an enthusiastic mineralogist and while in Europe made the most extensive and valuable collection of minerals ever brought to America, embracing more than twenty thousand specimens. Having found in Professor Silliman a zealous and sympathetic student in his favorite science, he proposed to install his cabinet at Yale College, if suitable accommodations were provided for it by the corporation. The proposition was promptly accepted, the cabinet was arranged under the personal supervision of its owner and it was then thrown open to the use of the college and the public. After fifteen years of free use of this collection, the college authorities purchased it for $20,000. It was a most profitable investment for the institution enabling it thus early to secure a prominence in mineralogy which under a distinguished line of mineralogists it has maintained ever since. Colonel Gibbs was also a very successful collector of minerals in this country, traveling widely for this purpose, freely gave of his time and knowledge to those interested in minerals, offered prizes to students making unusual attainments in the science, contributed important papers in scientific periodicals and in other ways proved a zealous promoter of interest in the study of mineralogy.

Hitherto little had been published in the English language that would serve as a text book for the schools. In England Kirwin's and Jameson's publications were either too old, or too much given to the defense of a particular phase of the subject, to be of value in securing a broad and up-to-date knowledge of the subject, but in 1816 Professor Parker Cleaveland of Bowdoin College published an Elementary Treatise on Mineralogy and Geology. It met with immediate general acceptance being of a high order of merit and receiving commendation even from the leading mineralogists of all Europe. Two editions were soon exhausted and a third was urgently called for, but unfortunately the author had been required to give his energies to the newly established Medical School at Brunswick and he could not respond to the demand, tho his lectures upon the subject were continued till his death which occurred in 1858. The feeling cannot be avoided that in his enforced withdrawal from a more exclusive devotion to the subject, mineralogy in America lost a masterly champion.

The good fortune of Yale in securing the very superior cabinet of Colonel Gibbs has already been noted. But as cabinets, any more than buildings and equipments, do not make a great school of themselves, Yale's good fortune would have availed but little without the directing and vitalizing powers and activities of a young man upon her faculty at that time, Professor Benjamin Silliman, who was one of the earliest to

take up the subject of Mineralogy with zeal and determination. Four years previous to the first opening of the Gibbs cabinets at New Haven he had secured for the institution the second best collection of minerals in the country, namely that of Mr. B. D. Perkins of New York. The reputation in mineralogy thus early secured by Yale and steadfastly maintained ever since, affords the best evidence of the wisdom on the part of an institution of securing the best obtainable in equipment and in men. The best is none too good.

Professor Silliman was instrumental in the establishment of the American Journal of Science in 1818. It was at once very helpful to all branches of science, but especially so to Mineralogy, to which special attention was given in all the earlier volumes. For more than fifty years he held the chair of Chemistry, Mineralogy and Geology, and when by reason of advancing years, he gave up the work, he had the pleasure of entrusting the two last named to the hands of James D. Dana who proved a worthy successor, as is abundantly evidenced by the fruits of his labors, both as teacher and author. His Geologies and Mineralogies long held the foremost place among American publications of their kind as authoritative exponents of the practical value and status of these two sciences. Since his retirement the chair of Mineralogy has been occupied by Professor George J. Brush and Samuel L. Penfield who have well maintained the high standard set by their distinguished predecessors.

The scope and intent of this paper forbids even the mention of many others who have gained a name and reputation as efficient promoters of the science of Mineralogy in America. At the risk of its seeming inappropriate in a gathering not distinctively pedagogical in its character, I cannot close, without making an earnest, tho brief, plea for a more general interest in the dissemination of at least a fair working knowledge of the commoner minerals and rocks. While mineralogy, perhaps, is receiving its share of consideration at the hands of investigators and of those who are carrying their studies into the advanced stages of the subject, popular interest in the common minerals and rocks is not as deep or general as it is in any of the other lines of science, unless it be astronomy. The same arguments that are made for a wider dissemination of knowledge of the facts and principals of the other sciences apply with equal, if not greater, force to mineralogy. Just as every one should be acquainted with the names and characteristics of the trees about him, so should he be familiar with the minerals likely to be met with any day and that enter into the make-up of the rocks of common occurrence and give to the soils their essential qualities. The idea is quite prevalent that an understanding of chemistry is essential to the acquirement of a practical knowledge of mineralogy. This is not so, of course. While chemistry is contributory to a full knowledge of minerals, they can be determined and known in a practical way by a study of their external qualities mainly, or wholly, and it is for such a study of them in our secondary schools at least that I would here enter my plea. The disciplinary results of such a study are especially to be commended as bearing most effectively upon the development not only of the observing faculties, but also in a still higher degree of the power of reflection and judgment.

I know of no branch of science in which a single term of well directed effort will result in more practical good both in training and knowledge than from the determination of minerals from a consideration of their external qualities mainly. Along with and included in this should go, of course, the recognition of the mineral constituents of the granites and other common rocks. Thereafter, with a well trained muscular sense in judging of weight and with no more apparatus than a knife-blade and a piece of glass for testing hardness, one, while in the field, may recognize with a fair degree of certainty a large percent of the minerals and rocks studied. Later with recourse to a bottle of acid for testing carbonates, a small magnet, an inexpensive balance for a more exact determination of specific gravity and a simple blow-pipe, all doubt may be removed respecting any of those that had been identified only tentatively and the most, if not all, of those too difficult for recognition in the field may thus be determined with assurance. The Mineralogy of today is established upon a well defined basis, occupies an important place among kindred sciences and should receive at the hands of educators a more universal recognition in the courses of secondary schools and colleges.

PHOTOGRAPHIC ACCESSORIES CF THE DRAKE OBSERVATORY.

BY D. W. MOREHOUSE.

The application of photography to astronomical research is one of the great achievements of science. While the "pioneering experiments" date back to the days of Dr. J. W. Draper and Warren de la Rue, the vastly interesting and valuable results belong to the present decade.

Astro-physics, "the new-born child of Astronomy", owes its phenomenal growth and development, if not its birth, to the photographic lens and camera.

It is certain that the sensitive plate will never be as satisfactory for general observations as the eye but it is vastly superior for some kinds of observations. Take the nebulae for example. Here the camera will obtain in the course of a few hours information and detail hopelessly beyond the power of any human eye. Moreover, it has no nerves or preconceived ideas; and you can depend upon its impressions.

The eight-and-one-fourth-inch equatorial of the Drake Observatory is equipped with a third or photographic lens. It was ground by Dr. J. A. Brashear, which fact alone is sufficient guarantee as to its quality. At the time the instrument was purchased, there was no provision made for a guiding telescope; and, as the exposures require hours in some instances, a guiding appartus is an absolute necessity. To obviate this deficiency, the small telescope or finder which is always attached to the side of a large telescope was pressed into service. One could hardly expect this to succeed, for it is ill adapted to the work in every respect. However, some fairly good results were obtained in this way; just enough to stimulate a great desire to do better. Feeling that it was not possible to do much better with the finder and that a new guiding telescope was entirely out of reach, I cast about for some solution of my problem; and I feel that I have happily found it in the simple and inexpensive right-angled eye-piece which I had attached to the side of my camera.

The heavy brass ring shown in Fig. 1 is rigidly attached to the eye end of the telescope by four heavy bolts and carries on its outer end the heavy camera box. The right-angled prism clearly shown in the cut overhangs the edge cf the photographic plate and reflects the image of the guide star into the magnifying eye-piece attached to the side of the box. Here the image is made to coincide, by means of slow motion screws, with the intersection of two fine spider-lines. These lines are illuminated by a small incandescent lamp contained in the eye-piece tube. Fig. 2 shows the camera in place and ready for an exposure.

By this simple device, I have a guiding telescope of the same aperture and focal length as my photographic, and just as rigid. Fig. 3 shows the observer at work. Of course, the strain on eye and nerve is so great that

one cannot stand at the camera for much longer than fifteen minutes at a time, and must be relieved by a second observer. If one night is not sufficient for the exposure, the camera can be closed, the telescope turned into its usual position, and when the next clear night arrives, the telescope can be pointed to the same place, and the images superimposed with perfect exactness. Thus the long hours of exposure may be continued from night to night.

Fig. 4 is a reproduction of the results of an eight-hour exposure on the beautiful nebula in Orion. While much of the nebula and fine details in the original negative are entirely lost, there is still more to be seen than could possibly be discerned by the eye in the same telescope. Many fine drawings of this nebula have been made by eminent astronomers; but the autographic record made on a sensitive plate is so vastly superior to anything that has been done by eye and hand that photography is said "to have definitely assumed the office of historiographer to the nebula". The extent of the prodigious object had not been guessed at until the camera exposed its true form and outlying appendages. Portions which are now known to belong to the same mass were catalogued as separate nebulae.

The photographs of stars and star-clusters are even more wonderful and interesting than those of the nebulae. Fig. 5 shows the result of a two-hour exposure on the Double Star-cluster, in Perseus. The central portions are not so clearly resolved as they would be in direct vision; but the number and extent of the stars belonging to the cluster could never have been known by visual methods alone. By comparison with photographs taken in the past, or those to be taken in the future, any change in the cluster, either toward condensation or disintegration, could be readily noted.

Pictures of the moon were among the earliest results of celestial photography. The old question of lunar change seems to have been solved by the chemical eye. "Henceforth, at any rate," as Miss Clerke so beautifully puts it, "the lunar volcanoes can scarcely, without notice taken, breath hard in their age-long sleep." In Fig. 6,, the crescent is shown as taken by means of the three-inch amplifying lens. The lens is the work of Dr. John A. Brashear. Fig. 7, however, was originally taken without amplification, the image of the whole moon being less than one inch in diameter. The negative was then enlarged to six inches in diameter.

The field for research work along the lines of celestial photography is unlimited; and the ambitious young astronomer finds here a new and promising guide for his energies.

MUNICIPAL HYGIENE—PART II—MILK.

BY C. O. BATES.

It is the purpose of this paper to help popularize the scientific facts that have been discovered by the research laboratories which are controlled and fostered by our national government and individual States of the Union, and by the laboratories of the denominational institutions of higher education. Vast sums of money are spent each year to maintain such work. No one can question their efficiency or practical value. Such knowledge is not prized as highly as it should be, nor are the discoveries as thoroughly known as they should be. The bulletins that are issued from the various stations are within the reach of everyone, they are absolutely free. Like streams that have their origin in the ice fields of remote mountains, they come in gentle cascades to satisfy the thirsty and revive life, and give hope for better and higher life. "Doth not Wisdom cry? and Understanding put forth her voice?" "She crieth at the gates, at the entry, at the coming, at the doors."

Legislation is not what is needed so much as education. The people have to understand and appreciate great truths before they will accept and apply them. A people cannot be brought up from Egypt to Palestine in a single day as legislators would sometimes have us believe. The food that first sustains our bodies, which is at once the most delicate and perfect food, and for which there is no substitute, demands the most serious and searching investigation that Science can give it. Statistics show that more than one-fourth of the human race die in infancy. The cause of this frightful mortality is largely due to the impure quality of milk.

Such things ought not to be. Surely the voice of Wisdom in our land today cries, "They are a people that know not my ways."

Next to water is milk in its importance to a municipality. The question of a pure milk supply during the last few years has received a great deal of consideration, due, in a large measure, to a feeling of alarm in the minds of those who have made thorough and scientific investigations.

Practically every city in the United States having a population of over 50,000 is beginning to have some sort of supervision of its milk supply, while nearly all of the smaller cities are falling into line with this movement.

Pure milk has a bland, sweet taste and is slighly alkaline in its reaction. Its color with yellow tinge is due to an emulsion of about sixteen different kinds of oils which constitute the butter fat. Pure milk is slightly heavier than pure water, its specific gravity being 1.03. The average composition of cows milk is as follows:

Water	87.2
Proteines	3.5
Fat	3.5
Sugar	4.9
Minerals	.7

It is thus shown by its chemical constituents to be a perfect food. It contains all the four classes of nutriments—minerals for building up and repairing bone tissue; proteines for nerve, sinew and muscle; fat for reserve energy; sugar for heat. The ingredients are found in the right proportion for a complete food.

There are many reasons why milk should receive special consideration. In a large sense there is no food so absolutely essential to our well-being as a people. It is the most readily assimilated of all foods. It is nature's food for the young of all mamal-. It is the most easily adulterated food, and the adulteration is frequently the most difficult to detect. It is one of the greatest absorbents of disagreeable and poisonous gases and odors.

If not properly cared for it soon deteriorates and under certain conditions tox-albumens are formed which render it dangerous. It is a veritable paradise for bacteria. Every drop of water that touches the milk furnishes its quota; every time that warm milk is exposed to the air, new micro-organisms find their home in the milk, and multiply with a rapidity that discounts the most incredible fairy story.

When once pathogenic germs get into milk an epidemic is started so quickly that we are scarcely able to cope with it. In case of typhoid epidemics, experts first direct their attention to the milk supply. This evil, as is the spreading of all other infectious diseases, is due to negligence, ignorance and carelessness, and a lack of proper supervision. The magnitude of this crime is appalling when we think of the number of very young children whose health is permanently injured, and the number whose lives are evidently lost by such adulterated food.

No one knows how much misery is produced, nor how many lives are lost when adulterated milk is administered to the sick.

The infants of today are the men and women of tomorrow. Our forefathers were stronger and hardier than we. One reason for this was certainly because they drank purer milk and purer water and breathed purer air.

The man who mixes glucose worth two cents a pound with honey worth twelve cents a pound practices deception and fraud, but there is no physicial injury done the customer. The glucose is just as wholesome as the honey. But the man who puts formaldehyde or any other preservative that injures its digestibility into the milk destroys the vitality of the nation.

Since milk is the most delicate food and fills such a large and important place in the basic demands for the sustenance and growth of our bodies, it of necessity requires a corresponding delicate care in handling in order to accomplish the expected results. In fact, the care of milk demands more than a passing consideration. It is the place to emphasize skill in manipulation, to use exquisite methods of cleanliness, and to focus all the knowledge that science has given us.

The average farmer spends a great deal of time each day in washing and grooming his fine horses, and he is to be commended for it. At the same time his cows receive little or no attention of this kind, while their bodies reek with the accumulation of dust, dirt and filth. This is wrong. The health and happiness of thousands are dependent upon the well groomed cow, the well kept barnyard, the clean barn, well lighted and ventilated , and supplied with an abundance of pure water.

The progress and intelligence of the twentieth century will not permit this evil to exist. Let us look at things just as they are and measure them according to their value. When a square deal is in effect with those things that have to do with the essential elements of our civilization and our well-being as free moral agents, the science of preparing pure milk

will be more highly esteemed than it is at the present time. Latin, Greek and the higher mathematics will be none the less valued, but the art of preparing pure food will be advanced many points. If the sages of the last century had given as much attention to micro-organisms as they did to the "final perseverence of the saints" and to "total depravity" we would certainly have been drinking purer milk at this time.

The sources of contamination of milk are many. Frequently some of them are evasive and baffle the skill of our present day scientists, while again other sources of contamination are so obvious as to offend our sense of common decency; especially it this true when we observe in the bottom of our glass or pitcher of milk dirt in its hideous forms. If each person is to eat his conventional "peck of dirt", let him avoid it in milk, because of the extreme danger of its being associated with malignant disease.

While the care of the body of the cow and the care of the barnyard is perhaps the most important matter for the consideration in the effort to obtain pure milk, the next most important consideration is the personal cleanliness of the milker. Many cases of contagious diseases have been traced to the home of milkmen. Impure water has been used in washing the milk cans or the utensils have not been sufficiently sterilized with boiling water. Pure milk from a healthy cow contains few bacteria, while milk that is taken from a slovenly kept cow in a foul, dark barn will have millions per cubic centimeter.

The crusade for pure milk which began some years ago, had its origin in the United States and in Switzerland with the milkmen themselves. This fact is both significant and hopeful.

If consumers would give more attention to pure milk than to cheap milk, the great cause would be helped immensely.

Common sense and decency tells us that all food products should be prepared clean and kept clean. It requires no scientific demonstration to show that dirt and fifth should be banished, but just how to fight and overcome such common foes demands the best skill of our boasted civilization. A child knows that fire will burn his hand, though he cannot understand the principles of combustion, much less comprehend the scientific meaning of heat. It is a well known fact to every housekeeper that milk will not keep as well as other foods. It will sour, curdle and decompose while all other foods retain their sweetness and purity. This fact has been known for ages, but the real cause was not understood until within the last two decades.

While all foods should be handled with care, extreme care is absolutely essential in the handling of milk. Science has demonstrated in the last few years that all the troublesome changes in milk are due to the presence of bacteria.

Success in handling milk depends upon two things:

First, the ability to keep bacteria from getting into the milk.

Second, the ability to control the bacteria that may have unavoidably gotten into the milk.

The science of dairying is based primarily upon the science of bacteriology. Bacteria are microscopic plants and perhaps are as numerous in genera and species as the visible vegetable kingdom. It is said that

the method of preparing Roquefort cheese was, like some other great discoveries, accidental. A lad in Switzerland was in the habit of taking his noon lunch with him while tending his father's herds. By chance one day he left his lunch in a cave. He was surprised some days later to find his lunch, and was especially pleased with the new flavor which the cheese had acquired. From that date to this Roquefort cheeses have been made in that cave by the inhabitants of that province.

This species of bacteria has also been grown in many other places wherever the dairymen wished to make this particular kind of cheese, just as Indian corn though originally found in America has been grown successfully in many parts of the world.

Bacteria are bought and sold in the market. They are used to ripen the cream, for making butter. They give a desirable flavor to the butter when the right species are used in the right way. Like weeds in the garden, pathogenic and troublesome bacteria seem to thrive where we do not want them. Warm temperature, moisture and food supply are the conditions that favor the wonderfully rapid growth of bacteria. The first step in the care of the milk is to cool it to a temperature of at least 50 degrees Fahrenheit or below, and keep it as cool as possible until it is ready to be used.

Since every cubic inch of air in a barnyard contains hundreds of bacteria, every particle of dust and every fiber are alive with these minute organisms, it is absolutely necessary to keep the milk carefully covered. It becomes easy to see, from the standpoint of bacteriology, that the milk should have special care. It is not necessary for every milkman to become an expert bacteriologist in order to furnish a pure supply of milk, but it would be extremely to his advantage to get the view point of the bacteriologist, and to keep posted on the progress of the science as developed by our various state experimental stations and our national bureau of chemistry. Pamphlets of the greatest value are issued from these stations at various times giving the most valuable and reliable information that can be obtained. Such documents are issued and designed primarily for those who are engaged in the dairy industry.

The following is the result of some bacteriological counts in the city milk of Cedar Rapids.

Date.	Milk.	No. of bacteria per cu. centim.
June 23, 1906	Sample No. 1.	475,000
" " "	" " 2.	365,400
" " "	" " 3.	150,000
" " "	" " 4.	730,000
" " "	" " 5.	145,600
" " "	" " 6.	283,000
" " "	" " 7.	232,000
" " "	" " 8.	534,000
" " "	" " 9.	440,000
" " "	" " 10.	266,000
July 2, "	" " 11.	800,000
" " "	" " 12.	130,000
" " "	" " 13.	484,000
" " "	" " 14.	208,000

CREAM.

June 23, 1906	Sample No. 1.	465,500
" " "	" " 2.	351,000
July 2, 1906	" " 3.	421,000
" " "	" " 4.	656,000
" " "	" " 5.	630,000

AN OBSERVATION ON THE NUMBER OF BACTERIA IN DES MOINES SCHOOL BUILDINGS.

BY L. S. ROSS.

At the request of the President of the Polk County Medical Society in November of last year, 1905, I made a little investigation into the bacteriological conditions of the school buildings of Des Moines.

Because of circumstances the work was hurriedly undertaken and because of that fact, was more crudely done than it otherwise would have been. Not having apparatus available for the determination of the number of bacteria in a measured quantity of air, and not having time to prepare such apparatus, it was necessary that the method adopted should be the rather crude one of exposing Petri dishes in the air of the school rooms for a definite period of time. It was also necessary that these dishes while being exposed, could not be under direct observation, consequently I do not know that in all instances they were all undisturbed, although I believe such to have been the case. For these reasons, then, it will be readily understood that results obtained can be considered only as approximate instead of being scientifically accurate. For a period of thirty minutes a Petri dish containing ordinary gelatine medium was exposed in each building, in the room that was the most crowded with pupils. At the beginning of the exposure of the dishes in the rooms selected for the purpose, the teachers gave the pupils a marching drill, or calisthenics—with one exception, that being in the case of the room in the West side high school in which the request was not made— in order that the dust of the room should be put into circulation. Teachers were requested to replace the covers on the dishes at the end of the allotted time and take them to the principal's office.

Upon the return of the gelatine dishes to the laboratory they were placed in the incubator room and kept at room temperature for a period of forty-eight hours, with the exception of some of the dishes, which unavoidably were permitted to stand sixty hours before the count of the colonies was taken. If the dishes had been permitted to incubate longer, the probability is that a larger number of colonies would have developed. As has already been stated, the determination of number per cubic meter could not be made by the method employed. The number of colonies on the gelatine plates exposed in the different buildings is as follows:

Benton, Room 1,	1,150
Bryant, Room 10,	504
Curtis, Room 5,	963
Bremer, Room 1,	375
Emerson, Room 5,	1,320
East High Assembly Room,	386
East High Toilet, Girls,	478
Lucas, Room 4,	784
Webster, Room 8,	435
Longfellow, Basement	695
Longfellow, Room 1,	415

This makes a list of the buildings in East Des Moines in which dishes were exposed.

The number of colonies on the plates exposed in the different buildings in West Des Moines is as follows:

Franklin, Room 7,	358
Irving, Room 5,	258
Bird, Room 5,	328
West High, Room 11,	98
Lincoln, Room 2,	460
Summit, Room 3,	235
Forrest, Room ?	355

The incubation period in the following buildings was sixty hours instead of forty-eight:

McKinley, Room 2.	325
Washington, Room 8,	615
Oakland, Room 10,	425
Garfield, Room 4	151
Crocker. Assembly Room	198
North High, Troutner Room	129

Leaving Room 11 of the High school out of the calculation the average number of colonies per dish exposed in the West side buildings was 322; in the East side buildings 677. With these counts as a basis I find that just after the dust of the rooms is put into circulation by the children marching, the bacteria fell to the floor at the rate of 7403 on one square foot of floor surface in one hour of time in the West side buildings and at the rate of 15570 on same area in same time in East side buildings. Considerable variation in numbers is noticeable in different buildings, the smallest number in any West side building being 129 the largest 615. In the East side buildings the corresponding numbers are 375 and 1320. Of course conditions of exposure of the dishes could not be identical in the various buildings. The location of the building affects, in considerable degree, the number of germs in the air. The fact that conditions under which the dishes were exposed could not be identical makes it evident at once that the number of colonies in the different buildings is not to be taken as an exact measure of the efficiency of the janitor service in the various buildings. Yet it does indicate with a greater or less degree of accuracy the relative condition of the rooms at the time when the exposures were made. The number of colonies developing in the dishes exposed in the East side buildings is approximately two times as great as the number of colonies developing in the dishes exposed on the West side. I attribute this difference to a great extent to the fact that the floors of the West side buildings are oiled, while those on the east side are not. Bacteria are heavier than air and consequently tend to fall to the ground or floor. If the surface of the floor is such that the dust and the bacteria adhere, then movement in the room as a natural consequence will fail to put much of the dust into circulation. No better illustration of the sticking of dust to an adhesive surface can be given than John Tyndall's classical experiment in 1876. If the surface of the

floor is moist, then the bacteria will adhere. So long as the dust and bacteria are moist they will not be taken up to any very great extent from the surface by ordinary air currents. It has been known for a number of years that the air in sewers is much more nearly pure bacteriologically than is the air of the street. It is not necessary to state that in order to keep the air of the school room as nearly free from bacteria as possible, the floor, the walls, and furniture must be kept as thoroughly cleansed from dust as practicable.

A FLORA OF WEBSTER COUNTY, IOWA.

COMPILED BY O. M. OLESON AND M. P. SOMES.

Webster county lies just north and west of the geographical center of Iowa and is somewhat larger than any of the surrounding counties having an area of 720 miles. The county is primarily a prairie county, its only forests being narrow strips along the streams. The average elevation of the county as a whole is about 1100 feet. Along the Des Moines River, which crosses the county from north to south, the forest fringe varies from a quarter of a mile to more than three miles in width and is made up of such trees as oak, hickory, elm, ash, basswood and the like. Both branches of Lizard Creek are wooded and Soldier Creek and most of the other streams have more or less of woods along them. The larger part of the surface of the county is open rolling prairie with a soil of "Wisconsin Drift" for the most part with a few morainic hills of coarse gravel, most noticeable in the northern parts of the county, but some isolated mounds in the south part are very striking.

The natural drainage system of the country is quite young and the stream systems are comparatively simple. As a result of these conditions marshes, ponds and sloughs of considerable area abound, although these areas are now being reclaimed by ditching.

In the southern part of the county the Des Moines and its tributaries flow through the "Coal Measures Sandstones" and their valleys are bounded by abrupt escarpments of the sandstone, with steep cliffs from forty to one hundred feet in height.

Another element which perhaps enters into the conditions producing such an abundant and varied series of plants here, is the fact that the portion of the country about Fort Dodge, in the central part of the county, is underlaid by beds many feet thick of gypsum or "land plaster" and while it has been contended that these underlying beds have no direct influence on the vegetation of this section, the fact still remains that the areas near the exposures of the gypsum beds, viz. the valley of "Two Mile Creek" or as it is more familiarly known "Gypsum-Hollow", and the Des Moines Valley near "Blanden's Mill" have an entirely distinctive flora from any other points, not only as to species but as to relative density of growth.

The plants listed in this Flora, which we know and acknowledge to be incomplete, are the result of the past three years work and while we have been able to examine the northern parts of the county carefully, we have not, by reason of the size of the county, been able to work out the southern parts as closely as we wish. We present this list however as a definite beginning and we expect to add to it from time to time as we may.

In connection with the title of this paper we wish to give here full credit to the work of Dr. C. H. Churchill of Fort Dodge, who has been intimately associated with us in the collecting and identifying of the plants here listed and we wish to explain that while Dr. Churchill is not yet a member of this Academy, and for that reason wished us to present this paper under our names only, yet he is entitled to full credit for his share in the work.

We wish to thank all our friends, both botanists and flower lovers, who have helped us in collecting and classifying. We wish especially to thank Professors Macbride and Shimek of the Iowa State University, Prof. L. H. Pammel of Iowa State College of Agriculture, Prof. Aven Nelson of State University of Wyoming and Mr. R. I. Cratty of Armstrong, Iowa, who have kindly assisted us with difficult species.

The nomenclature of this list follows that of the first edition of Britton's Manual of the Flora of the Northern U.S. and Canada except in the case of one or two species not listed in that work.

Practically all of the species listed herein are represented by specimens in the Herbarium of The Webster County Botanical Club of Fort Dodge and while we realize that some of these species are far from their homes as designated by the range given in the texts, we can only plead that the plants are,apparently,not strict respecters of the limits placed upon them.

SUBKINGDOM PTERIDOPHYTA

ORDER FILICALES

OPHIOGLOSSACEAE.

BOTRYCHIUM.

1. *B. virginianum* (L.) Sw. Common in rich woods.

OSMUNDACEAE.

OSMUNDA.

2. *O. cinnamonea* L. Rare in woods.
3. *O. claytoniana* L. Plenty in woods.

POLYPODIACEAE.

POLYODIUM.

4. *P. vulgare* L. Scarce in rocky places.

ADIANTUM.

5. *A. pedatum* L. Common in woods.
6. *A. capillus-veneris* L. Very rare.

CRYPTOGRAMMA.

7. *C. stelleri* (Gmel) Prantl. Rare. (*Pellaea stelleri* [S. G. Gmel] Watt.)

ASPLENIUM.

8. *A. filix-foemina* (L.) Bernh.

Camptosorus.

9. *C. rhizophyllus* (L.) Link. Scarce on rocks.

Dryopteris.

10. *D. thelypteris* (L.) A. Gray.
11. *D. cristata* (L.) A. Gray. Rare.
12. *D. goldieana* (Hook) A. Gray. Plenty.
13. *D. spinulosa* (Retz) Kuntze. Rare.

Filix.

14. *F. bulbifera* (L.) Underw. Plenty in woods.
15. *F. fragilis* (L.) Underw. Abundant in woods.

Woodsia.

16. *W. ilvensus* (L.) R. B. Very rare.
17. *W. obtusa* (Spreng) Torr. Abundant in woods.

Mateuccia.

18. *M. struthiopteris* (L.) Todaro. Plenty. [*Onoclca struthiopteris* (L.) Hoffm.]

Onoclea.

19. *O. sensibilis* L. Scarce.

ORDER EQUISETALES

EQUISETACEAE.

Equisetum.

20. *E. arvense* L.
21. *E. pratense* Erhr.
22. *E. sylvaticum.*
23. *E. fluviatile* L.
24. *E. robustum* A. Br.
25. *E. hyemale* L.
26. *E. laevigatum* A. Br.

SUBKINGDOM SPERMATOPHYTA.

CLASS I GYMNOSPERMAE.

PINACEAE.

Juniperus.

27. *J. virginiana* L. Almost extinct; formerly plenty.

CLASS II ANGIOSPERMAE.

TYPHACEAE

Typha.

28. *T. latifolia* L. Common in swamps and marshes.

SPARGANIACEAE.

Sparganium.

29. *S. eurycarpum* Engelm. Common in swamps.
30. *S. androcladum* (Engelm) Morong. Rare.
31. *S. simplex* Huds. Scarce.

NAIADACAE.

POTAMOGETON.

32. *P. natans* L.
33. *P. lonchites* Tuckerm.
34. *P. foliosus* Raf.
35. *P. pusillus* L. Rare.

ZANNICHELLIA.

36. *Z. palustris* L. Rather scarce.

NAIAS.

37. *N. flexilis* (Willd) Rost. & Schmidt. Rather scarce.

ALISMACEAE.

ALISMA.

38. *A. plantago-aquatica* L. Common in swamps and marshes.

SAGITTARIA.

39. *S. longirostra* (Micheli) J. G. Smith. Plenty.
40. *S. latifolia* Willd. Common.
41. *S. arifolia* Nutt.
42. *S. graminea* Michx. Plenty.

VALLISNERIACEAE.

PHILOTRIA.

43. *P. canadensis* (Michx.) Britton.

GRAMINEAE.

ANDROPOGON.

44. *A. scoparius* Michx.
45. *A. furcatus* Muhl.

SORGHASTRUM.

46. *S. avenaceum* Nash.
    [*Chrysopogon avenaceus* (Michx.) Benth.]

SYNTHERISMA.

47. *S. linearis* (Krock) Nash.
48. *S. sanguinalis* (L) Dulac. Common marshy places.

ECHINOCHLOA.

49. *E. crus-galli* (L) Beauv. Abundant.
    (*Panicum crus-galli* L.)

PANICUM.

50. *P. capillare* L. Commen.
51. *P. virgatum* L. Plenty.
52. *P. pubescens* Lam.
53. *P. miliaceum* L.
54. *P. liebergii* (Vasey(Scribn.
55. *P. scribnerianum* Nash.
56. *P. macrocarpon* LeConte.

CHAETOCHLOA.

57. *C. verticillata* (L). (*Ixophorus verticillatus* (L) Nash.)

58. *C. glauca* (L) Schibn. (*Ixophorus glaucus* (L) Nash.)

59. *C. viridis* (L) Scribn. (*Ixophorus viridis* (L) Nash.)

60. *C. italica* (L) Scribn. (*Ixophorus italicus* (L) Nash.)

CENCHRUS.

61. *C. tribuloides* L. Abundant on sandy soil.

ZIZANIA.

62. *Z. aquatica* L. Plenty, though not so abundant as formerly

HOMALOCENCHRUS.

63. *H. virginicus* (Willd) Britton. Plenty in damp places.

64. *H. oryzoides* (L) Poll. Common in swamps.

PHALARIS.

65. *P. arundinacea* L. Frequent in marshes.

SAVASTANA.

66. *S. odorata* (L) Scribn.

ARISTIDA.

67. *A. basiramea* Engelm. Scarce. In dry places.

STIPA.

68. *S. spartea* Trin.

ORYZOPSIS.

69. *O. melanocarpa* Muhl. Rocky woods.

MUHLENBERGIA.

70. *M. sobolifera* (Muhl) Trin. In rocky woods.

71. *M. racemosa* (Michx.) B. S. P. Plenty in moist places.

72. *M. mexicana* (L) Trin. Common in wet places.

73. *M. tenuiflora* (Willd) B. S. P.

74. *M. diffusa* Schreb. On dry hillsides.

BRACHYELYTRUM.

75. *B. erectum* (Schreb) Beauv. Scarce in moist places.

PHLEUM.

76. *P. pratense* L. Common.

ALOPECURUS.

77. *A. geniculatus* L. Scarce in marshy meadows.

SPOROBOLUS.

78. *S. neglectus* Nash.

79. *S. airoides* Torr.

80. *S. heterolepsis* A. Gray.

81. *S. asperifolius* Nees & Meyen.

AGROSTIS.

82. *A. alba* L. Abundant everywhere.

83. *A. perennans* (Walt.) Tcukerm. Along streams, etc.

84. *A. hyemalis* (Walt.) B. S. P. Common.

CALAMAGROSTIS.

85. *C. canadensis* (Michx) Beauv. Common in wet meadows.

DANTHONIA.

86. *D. spicata* (L) Beauv. Plenty in dry woods.

SPARTINA.

87. *S. cynosuroides* (L) Willd. Common in swamps and marshes.

BOUTELOUA.

88. *B. hirsuta* Lag. Locally plenty.

ATHEROPOGON.

89. *A. curtipendulus* (Michx) Fourn. Plenty on prairies. (*Bouteloua curtipendula* (Michx.) Torr.]

PHRAGMITES.

90. *P. phragmites* (L) Karst. Common in marshes.

TRICUSPIS.

91. *T. seslerioides* (Michx.) Torr. (*Sieglingia sesleroides* (Michx) Scribn.)

DIPLACHNE.

92. *D. fascicularis* (Lam.) Beauv. Rare. In a brackish marsh.

ERAGROSTIS.

93. *E. capillaris* (L) Nees. In dry places.

94. *E. purshii* Schrad. Abundant in dry waste ground.

95. *E. major* Host. Cultivated and abundant in waste places.

96. *E. hypnoides* (Lam.) B. S. P. Common along muddy banks of streams.

EATONIA.

97. *E. obtusata* (Michx.) A. Gray. Plenty in dry places.

98. *E. pennsylvanica* (DC.) A. Gray. Not so common as above.

KOELERIA.

99. *K. cristata* (L) Pers. Abundant on dry prairies.

MELICA.

100. *M. diffusa* Pursh. Plenty.

KORYCARPUS.

101. *K. diandrus* (Michx.) Kuntze. In rich woods.

DACTYLIS.

102. *D. glomerata* L. Scarce.

POA.

103. *P. pratensis* L. Abundant.

104. *R. debilis* Torr. In open woods.

PANICULARIA.

105. *P. nervata* (Willd.) Kuntze. Plenty in swamps and marshes. (*Glyceria nervata* Trin.)

106. *P. americana* (Torr.) (*Glyceria grandis* S. Watts.)

107. *P. fluitans* (L) Kuntze. Plenty in marshes. (*Glyceria fluitans* R. R. Br.)

FESTUCA.

108. *F. octoflora* Walt.

BROMUS.

109. *B. ciliatus* L. Plenty in woods.

110. *B. kalmii* A. Gray. Plenty in woods and thickets.

111. *B. secalinus* L. Scarce in fields.

112. *B. breviaristatus* (Hook) Buckl. Very rare.

AGROPYRON.

113. *A. glaucum* R. & S.

114. *A. tenerum* Vasey. Plenty in dry soil.

HORDEUM.

115. *H. jubatum* L. Abundant. A very troublesome weed.

ELYMUS.

116. *E. striatus* Willd. In open woodlands.
117. *E. virginicus* L. Common along streams.
118. *E. canadensis* L. Common in moist fields and along streams.
119. *E. robustus* Scribn. & Sm. Common in moist places.

HYSTRIX.

120. *H. hystrix*. Common in woods.

CYPERACEAE.

CYPERUS.

121. *C. diandrus* Torr. In marshes.
122. *C. rivularis* Kunth. Along streams.
123. *C. inflexus* Muhl. Plenty along streams.
124. *C. schweinitzii* Torr. Rare.
125. *C. erythrorhizos* Muhl. In wet meadows.
126. *C. speciosus* Vahl. Plenty in marshes.
127. *C. strigosus* L. Common in swamps.
128. *C. filiculmis* Vahl. Dry fields.

ELEOCHARIS.

129. *E. atropurpurea* (Retz.) Kunth. Plenty in marshy places.
130. *E. palustris* (L.) R. & S.
131 *E. palustris, glaucescens* (Willd.) Gray.
132. *E. acicularis* (L.) R. & S.

SCIRPUS.

133. *S. americanus* Pers.
134. *S. lacustris* L. Common in marshes.
135. *S. fluviatilis* (Torr.) Gray. Abundant along edges of streams.
136. *S. atrovirens* Muhl. Abundant in marshy places.
137. *S. lineatus* Michx. In swamps and marshes.

ERIOPHORUM.

138. *E. polystachyon* L. Scarce in marshy places.
139. *E. gracile* Koch. Rare in marshy places.

FUIRENA.

140. *F. squarrosa* Michx. Scarce in marshes.

HEMICARPA.

141. *H. micrantha* (Vahl.) Britton. Rare in marshes.

CAREX.

142. *C. retrorsa* Schwein.
143. *C. hystricina* Muhl. Plenty in swamps.
144. *C. comosa* Boott. In swamps.
145. *C. trichocarpa* Muhl. Plenty in swamps.
146. *C. aristata* R. Br. Scarcer than above species.
147. *C. lanuginosa* Michx. Quite common in swamps.
148. *C. stricta, angustata* (Boott) Bailey.
149. *C. fusca* All. In wet places.
150. *C. aquatilis* Wahl. Rare in marshy places.

151. *C. longirostris* Torr.
152. *C. grisea* Wahl. Scarce in woods.
153. *C. conoidea* Schk.
154. *C. oligocarpa* Schk. In woods.
155. *C. hitchcockiana* Dewey. In woods.
156. *C. meadii* Dewey.
157. *C. laxiflora, blanda* (Dewey) Boott. Scarce in thickets.
158. *C. digitalis* Willd. In woods.
159. *C. albursina* Sheldon. Plenty in woods.
160. *C. setifolia* (Dewey) Britton.
161. *C. pennsylvanica* Lam. In dry soil.
162. *C. pubescens* Muhl. In woods.
163. *C. stipata* Muhl. Common. Fields and marshes.
164. *C. rosea* Schk. Common in woods.
165. *C. rosea, radiata* Dewey. Scarce in woods.
166. *C. gravida* Bailey.
167. *C. vulpinoidea* Michx. Abundant.
168. *C. sparganioides* Muhl. In woods.
169. *C. cephalophora* Muhl. In dry soil.
170. *C. deweyana* Schwein. Rare.
171. *C. cristatella* Britton. Abundant in meadows.
172. *C. straminea* Willd. In dry soil.
172. *C. festucacea* Willd. Plenty in meadows.
174. *C. bicknellii* Britton.

ARACEAE.

ARISAEMA.

175. *A. triphyllum* (L) Torr. Abundant in moist woods.
176. *A. dracontium* (L) Schott. Scarce in rich woods.

LEMNACEAE.

SPIRODELA.

177. *S. polyrhiza* (L) Schleid. Scarce in ponds.

LEMNA.

178. *L. trisulca* L. Common in ponds.

COMMELINACEAE.

TRADESCANTIA.

179. *T. virginiana* L. Abundant.
180. *T. reflexa* Raf. Some rather doubtful specimens apparently belong to this species but were too old when found.

PONTEDERIACEAE.

HETERANTHERA.

181. *H. dubia* (Jacq) MacM. Rare in swamps.

JUNCACEAE.

JUNCUS.

182. *J. effusus* L. Abundant in swamps and marshes.
183. *J. balticus* Willd. Rare.
184. *J. tenuis* Willd. Abundant.
185. *J. marginatus* Rostk. Plenty.
186. *J. nodosus* L. Plenty in moist soil.
187. *J. torreyi* Coville. Plenty.

MELANTHACEAE.

UVULARIA.

188. *U. grandiflora* J. E. Smith. Common in rich woods.

LILACEAE.

ALLIUM.

189. *A. tricoccum* Ait. Common in woods Flowers rarely noticed as the broad leaves have disappeared before flowering time.
190. *A. stellatum* Ker. Abundant on open prairies.
191. *A. canadense* L. Plenty.

LILIUM.

192. *L. philadelphicum* L. Common in thickets. Some forms here appear to approach *L. umbellatum* Pursh. in appearance and in habitat.
193. *L. canadense* L. Common in meadows. Ours are mostly of the red flowered form.

ERYTHRONIUM.

194. *E. albidum* Nutt. Abundant in moist woods.

CONVALLARIACEAE.

ASPARAGUS.

195. *A. officinalis* L. Escaped from cultivation.

VAGNERA.

196. *V. racemosa* (L) Morong. Abundant in rich woods.
197. *V. stellata* (L) Morong. Abundant in woods and fields.

UNIFOLIUM.

198. *U. canadense* (Desf.) Greene. Scarce in rich woods.

SALOMONIA.

199. *S. biflora* (Walt.) Britton. Scarce in woods.
200. *S. commutata* (R & S) Britton. Common in woods and fields.

TRILLIUM.

201. *T. nivale* Riddell. Abundant in rich woods.
202. *T. cernuum* L. Rare in rich woods.
203. *T. erectum* L. Rare in rich woods.

SMILACEAE.

SMILAX.

204. *S. herbacea* L. Plenty in woods.
205. *S. ecirrhata* (Engelm) S. Wats. Plenty in woods.
206. *S. rotundifolia* L. Common along streams and in woods.
207. *S. hispida* Muhl. In thickets.

AMARYLLIDACEAE.

HYPOXIS.

208. *H. hirsuta* (L.) Coville. Abundant, not only in dry soil but in marshy meadows as well.

DIOSCOREACEAE.

DIOSCOREA.

209. *D. villosa* L. Plenty in thickets.

IRIDACEAE.

IRIS.

210. *I. versicolor* L. Abundant in swamps and marshes.

SISYRINCHIUM.

211. *S. angustifolium* Miller. Abundant in fields and meadows.

ORCHIDACEAE.

CYPRIPEDIUM.

212. *C. candidum* Willd. Scarce in meadows; formerly abundant.
213. *C. hirsutum* Mill. Scarce in woods. Occasionally very large plants over 1 m. have been noted.

GALEORCHIS.

214. *G. spectabilis* (L.) Rydb. Rare in rich woods. (*Orchis spectabilis* L.)

COELOGLOSSUM.

215. *C. bracteatum* (Willd.) Parl. Rare in woods and meadows. (*Habenaria bracteata* (Willd.) R. Br.)

BLEPHARIGLOTTIS.

216. *B. leucophaca* (Nutt.) Rydb. Plenty on open prairie. (*Habenaria leucophaea* (Nutt.) Gray.)

GYROSTACHYS.

217. *G. cernua* (L.) Kuntze. Plenty in moist meadows. Ours is a very stout form and seldom over 4 dm. high.

SALICACEAE.

POPULUS.

218. *P. alba* L. Rather scarce.
219. *P. balsamifera* L. Scarce.
220. *P. dilatata* Ait. Escaped from cultivation.
221. *P. deltoides* Marsh. Plenty.
222. *P. grandidentata* Michx.
223. *P. tremuloides* Michx. Plenty.

Salix.

224. *S. nigra* Marsh. Scarce.
225. *S. omygdaloides* Anders.
226. *S. lucida* Muhl.
227. *S. alba, vitellina* (L) Koch. Escaped from cultivation.
228. *S. cordata* Muhl. Plenty in marshy places.
229. *S. fluviatilis* Nutt. Abundant along streams.
230. *S. discolor* Muhl. In marshy places.
231. *S. humilis* Marsh. Common on open prairie.
232. *S. tristis* Ait. In dry rocky woods.
233. *S. candida* Fluegge.

JUGLANDACEAE.

Juglans.

234. *J. nigra* L. Comparatively scarce in woods.
235. *J. cinerea* L. Much more common.

Hicoria.

236. *H. ovata* (Mill.) Britton. Common in woods.
237. *H. laciniosa* (Michxf.) Sarg. Scarce in woods.
238. *H. glabra* (Mill.) Britton. Abundant in woods.

BETULACEAE.

Carpinus.

239. *C. caroliniana* Walt. Plenty in woods.

Ostrya.

240. *O. virginiana* (Mill.) Willd. Abundant in woods.

Corylus.

241. *C. americana* Walt. Abundant in woods.

FAGACEAE.

Quercus.

242. *Q. rubra* L. Plenty in woods.
243. *Q. palustris* DuRoi. Scarce. In marshy woods.
244. *Q. schneckii* Britton. Scarce.
245. *Q. coccinea* Wang. Plenty.
246. *Q. borealis* Michx. Scarce in woods.
247. *Q. velutina* Lam. Common in woods.
248. *Q. alba* L. Common in woods.
249. *Q. macrocarpa* Michx. Abundant in woods.
250. *Q. platanoides* (Lam.) Sudw. Scarce.

ULMACEAE.

Ulmus.

251. *U. americana* L. Abundant.
252. *U. racemosa* Thomas. Not so common as above.
253. *U. fulva* Michx. Abundant in woods.

Celtis.

254. *C. occidentalis* L. Plenty in woods.

MORACEAE.

HUMULUS.
255. *H. lupulus* L. Abundant in thickets.

CANNABIS.
256. *C. sativa.* L. L. Abundant along roadsides and in waste places.

URTICACEAE.

URTICA.
257. *U. dioica* L. Scarce. In waste places.
258. *U. gracilis* Ait. Common.

URTICASTRUM.
259. *U. divaricatum* (L) Kuntze. Common in woods.

ADICEA.
260. *A. pumila* (L.) Raf. Abundant in damp places.

BOEHMERIA.
261. *B. cylindrica* (L.) Willd. Common in damp places.

PARIETARIA.
262. *P. pennsylvanica* Muhl. Common in damp woods.

SANTALACEAE.

COMANDRA.
263. *C. umbellata* (L.) Nutt. Abundant. Along railways, etc.

ARISTOLOCHIACEAE.

ASARUM.
264. *A. acuminatum* (Ashe) Bicknell. Common in rich woods.
265. *A. reflexum ambiguum* Bicknell. Plenty in woods.

POLYGONACEAE.

RUMEX.
266. *R. acetosella* L. Abundant in fields and meadows.
267. *R. verticillatus* L. Plenty in swamps.
268. *R. altissimus* Wood. Plenty in wet places.
269. *R. britannica* L. Plenty in swamps.
270. *R. occidentalis* S. Wats. Rare in wet places.
271. *R. crispus* L. Quite abundant.
272. *R. sanguineus* L. Scarce.
273. *R. persicaroides* L. Scarce in swampy places.

FAGOPYRUM.
274. *F. fagopyrum* (L.) Karst. Escaped from cultivation.

POLYGONUM.
275. *P. amphibium* L. Scarce in ponds.
276. *P. hartwrightii* A. Gray. Common in swamps and marshes.
277. *P. emersum* (Michx.) Britton. Abundant at edges of swamps.
278. *P. incarnatum* Ell.
279. *P. lapathifolium* L. Along streams.
280. *P. lapathifolium, nodosum* (Pers) Small.

281. *P. pennslvanicum* L.
282. *P. persicaria* L. Plenty.
283. *P. persicaroides* H. B. K.
284. *P. opelousanum* Riddell. Scarce.
285. *P. hydropiperoides* Michx. Abundant in swampy places.
286. *P. hydropiper* L. Plenty in swampy places.
287. *P. punctatum* Ell. Plenty.
288. *P. orientale* L. Escaped from gardens.
289. *P. virginianum* L. Scarce.
290. *P. aviculare* L. Common.
291. *P. littorale* Link.
292. *P. rayi* Babingt.
293. *P. exsertum* Small.
294. *P. ramoissimum* Michx.
295. *P. camphorum* Meisn. Rare; on sandy hills.
296. *P. tenue* Michx.
297. *P. convolvulus* L.
298. *P. scandens* L.

CHENOPODIACEAE.

CHENOPODIUM.

299. *C. album* L. Abundant everywhere. Very variable in form.
300. *C. glaucum* L. Rare in waste places.
301. *C. boscianum* Moq. Plenty in woods.
302. *C. hybridum* L. Plenty in waste places.
303. *C. bonus-henricus* L. Scarce. In wet places.

CYCLOLOMA.

304. *C. atriplicifolium* (Spreng.) Coult. Scarce in sandy soil.

ATRIPLEX.

305. *A. patula* L. Scarce. In waste places.
306. *A. hastata* L. Scarce in waste places.

SALSOLA.

307. *S. tragus* L. Scarce; hardly holds its own.

AMARANTHACEAE.

AMARANTHUS.

308. *A. retroflexus* L. Abundant everywhere.
309. *A. hybridus* L. Rather scarce.
310. *A. hybridus, paniculatus* (L.) Uline & Bray. Scarce.
311. *A. blitoides* S. Wats. Common everywhere.
312. *A. graecizans* L. Scarce; formerly abundant.

ACNIDA.

313. *A. tamariscina* (Nutt.) Wood.

NYCTAGINACEAE.

ALLIONIA.

314. *A. nyctaginea* Michx. Abundant.
315. *A. hirsuta* Pursh. Rather scarce in dry fields.

AIZOACEAE.

MOLLUGO.

316. *M. verticillata* L. Scarce.

PORTULACACEAE.

CLAYTONIA.

317. *C. virginica* L. Abundant in rich woods. Some forms approach *C. caroliniana* Michx.

PORTULACA.

318. *P. oleracea* L. Abundant in fields and gardens.

CARYOPHYLLACEAE.

AGROSTEMMA.

319. *A. githago* L. Rare in fields.

SILENE.

320. *S. stellata* (L.) Ait. Abundant.

321. *S. antirrhina* L. Common in waste places.

322. *S. noctiflora* L. Rare along railways.

LYCHNIS.

323. *L. alba* Mill. Plenty in waste places.

SAPONARIA.

324. *S. officinalis* L. Scarce. Escaped from gardens.

VACCARIA.

325. *V. vaccaria* (L.) Britton. Rare in waste places.

ALSINE.

326. *A. longifolia* (Muhl) Britton. Plenty in rich woods.

327. *A. media* L. Abundant.

CERASTIUM.

328. *C. vulgatum* L. Common in woods and fields.

ANYCHIA.

329. *A. canadense* (L.) B. S. P. Common in woods.

NYMPHACEAE.

NYMPHAEA.

330. *N. advena* Soland. Common in swamps and marshes.

CASTALIA.

331. *C. tuberosa* (Paine) Greene. Plenty in ponds.

CERATOPHYLLACEAE.

CERATOPHYLLUM.

332. *C. demersum* L. Scarce in swamps and marshes.

RANUNCULACEAE.

CALTHA.

333. *C. palustris* L. Abundant in swamps.

ISOPYRUM.

334. *I. biternatum* (Raf.) T. & G. Abundant.

ACTAEA.

335. *A. rubra* (Ait.) Willd. Plenty in rich woods.

AQUILEGIA.

336. *A. canadensis* L. Abundant in rocky woods.

DELPHINIUM.

337. *D. carolinianum* Walt. Plenty on prairies.

338. *D. tricorne* Michx. Plenty.

339. *D. albescens* Rydb. Abundant on prairies.

ANEMONE.

340. *A. caroliniana* Walt. Plenty on prairies.

341. *A. cylindrica* A. Gray. Abundant in fields and open woods.

342. *A. virginiana* L. Scarce; open prairies.

343. *A. canadensis* L. Abundant everywhere.

344. *A. quinquefolia* L. Plenty in rich woods.

HEPATICA.

345. *H. acuta* (Pursh) Britton. Abundant in rich woods.

SYNDESMON.

346. *S. thalictroides* (L.) Hoffm. Scarce in rich woods.

PULSATILLA.

347. *P. hirsutissima* (Pursh.) Britton. Plenty on prairie hillsides.

CLEMATIS.

348. *C. virginiana* L. Abundant in woods and thickets.

RANUNCULUS.

349. *R. delphinifolius* Torr. Abundant in swamps. The variety "*terrestris*" is occasionally found.

350. *R. ovalis* Raf. Plenty on open prairie.

351. *R. abortivus* L. Abundant in woods and fields.

352. *R. sceleratus* L. Scarce in swamps.

353. *R. recurvatus* Poir. Plenty in rocky woods.

354. *R. septentrionalis* Poir. Abundant in swamps and moist meadows.

355. *R. hispidus* Michx.

356. *R. fascicularis* Muhl. Abundant on prairies.

BATRACHIUM.

357. *B. divaricatum* (Schrank.) Wimm. Rare in ponds.

OXYGRAPHIS.

358. *O. cymbalaria* (Pursh) Prantl. Abundant in swamps.

THALICTRUM.

359. *T. dioicum* L. Scarce in rocky woods.

360. *T. purpurascens* L. Abundant in woods.

361. *T. polygamum* Muhl. Abundant.

BERBERIDACEAE.

BERBERIS.

362. *B. vulgaris* L. Scarce in woods and thickets.

CAULOPHYLLUM.

363. *C. thalictroides* (L.) Michx. Common in rich woods.

MENISPERMACEAE.

MENISPERMUM.

364. *M. canadense* L. Abundant in woods and along streams.

PAPAVERACEAE.

SANGUINARIA.

365. *S. canadensis* L. Very abundant in rich woods.

BICUCULLA.

366. *B. cucullaria* (L.) Millsp. Very abundant.

367. *B. canadensis* (Goldie) Millsp. Rare in rich woods.

ADLUMIA.

368. *A. fungosa* (Ait.) Greene. Sparingly escaped from gardens.

CAPNOIDES.

369. *C. aureum* (Willd.) Kuntze. Abundant in sandy soil.

370. *C. curvisiliqum* (Engelm.) Kuntze. Rare.

CRUCIFERAE.

LEPIDIUM.

371. *L. virginicum* L. Scarce in waste places.

372. *L. apetalum* Willd. Abundant in fields and along roadsides.

THLASPI.

373. *T. arvense* L. Scarce in waste places.

SISYMBRIUM.

374. *S. officinale* (L.) Scop. Abundant.

375. *S. altissimum* L. Plenty.

BRASSICA.

376. *B. nigra* (L.) Koch. Abundant in fields and waste places.

377. *B. arvensis* (L.) B. S. P. Scarcer than above.

378. *B. campestris* (L). Scarce along railway right-of-way.

RORIPA.

379. *R. palustris* (L.) Bess. Abundant in swamps and marshes.

380. *R. hispida* (Desv) Britton. Not so common.

381. *R. nasturtium* (L.) Rusby. Rather scarce in brooks and streams.

382. *R. armoracia* (L.) A. S. Hitchcock. Escaped from gardens.

CARDAMINE.

383. *C. pennsylvanica* Muhl. Plenty in moist soil.

384. *C. flexuosa* With. Scarce in wet woods.

385. *C. bulbosa* (Schreb.) B. S .P. Common in swamps and marshes.

DENTARIA.

386. *D. laciniata* Muhl. Abundant in rich woods.

BURSA.

387. *B. bursa-pastoris* (L.) Britton. Abundant everywhere.

CAMELINA.

388. *sativa* (L.) Crantz. Scarce in waste places.

NESLIA.

389. *N. paniculata* (L) Desv. Very rare in Iowa.

DRABA.

390. *D. caroliniana micrantha* (Nutt.) A. Gray. Abundant on prairies.

SOPHIA.

391. *S. pinnata* (Willd.) Britton. Abundant in dry soil.
392. *S. intermedia* Rydb. Scarcer.

STENOPHRAGMA

393. *S. thaliana* (L.) Celak. Rare in rocky woods.

ARABIS.

394. *A. dentata* T. & G. Rather scarce in rich woods.
395. *A. canadensis* L. Abundant in rich woods.
396. *A. glabra* (L.) Bernh. Rare in fields.
397. *A. hirsuta* (L.) Scop. Plenty in rocky woods.

ERYSIMUM.

398. *E. cheiranthoides* L. Plenty along streams.

HESPERIS.

399. *H. matronalis* L. Rare, escaped from gardens.

CAPPARIDACEAE.

POLANISIA.

400. *P. graveolens* Raf. Very rare along streams.
401. *P. trachysperma* T. & G. Scarce on prairies.

PENTHORACEAE.

PENTHORUM.

402. *P. sedoides* L. Abundant in moist places.

SAXIFRAGACEAE.

HEUCHERA.

403. *H. hispida* Pursh. Abundant.

MITELLA.

404. *M. diphylla* L. Plenty in deep ravines.

GROSSULARIACEAE.

RIBES.

405. *R. cynosbati* L. Common in woods.
406. *R. missouriensis* Nutt. Plenty in woods.
407. *R. uva crispa* L. Scarce; escaped from gardens.
408. *R. floridum* L'Her. Plenty in woods and along streams.
409. *R. aureum* Pursh. In thickets.

ROSACEAE.

RUBUS.

410. *R. americanus* (Pers.) Britton. Quite rare in moist woods.
411. *R. strigosus* Michx. Plenty in dry woods.
412. *R. occidentalis* L. Common in rocky woods.
413. *R. canadensis* L. Rare in rocky woods.

DRYMOCALLIS.

414. *D. arguta* (Pursh.) Rydb. Abundant in dry soil.

FRAGARIA.

415. *F. virginiana grayana* (Vilm.) Rydb. Rather scarce. (*F. vi*
giniana illinoensis Gray.)

416. *F. americana* (Porter) Britton. Quite abundant. (*F. vesc*
americana Porter.)

COMARUM.

417. *C. palustre* L. Scarce in swamps.

POTENTILLA.

418. *P. argentea* L. Rare. Very rare in Iowa.

419. *P. monspeliensis* L. Common.

420. *P. pentandra* Engelm. Rather scarce.

421. *P. leucocarpo* Rydb. Rare in damp soil.

422. *P. canadensis* L. Plenty in dry woods.

GEUM.

423. *G. canadense* Jacq. Abundant in rich woods.

424. *G. virginianum* L. Rare in moist fields.

425. *G. strictum* Ait. Scarce in moist fields.

AGRIMONIA.

426. *A. hirsuta* (Muhl.) Bicknell. Abundant in woods and thicket
(A. *eupatoria hirsuta* Muhl.)

427. *A. mollis* (T. & G.) Britton. Scarce in woods and thickets. (*A*
eupatoria mollis T. & G.)

ROSA.

428. *R. setigera* Michx. Some doubtful specimens, placed here unt
further investigation.

429. *R. blanda* Ait. Scarce in rocky soil.

430. *R. arkansana* Porter. Abundant on prairies and along stream

431. *R. woodsii* Lindl. Scarce on dry prairies. (*R. fendleri* Crepin

432. *R. rubiginosa* L. Scarce; escaped from gardens.

POMACEAE.

MALUS.

433. M. *ioensis* (Wood.) Britton. Abundant. (*Pyrus coronari*
ioensis Wood.

AMELANCHIER.

434. *A. canadensis* (L.) Medic. Abundant.

CRATAEGUS.

435. *C. crus-galli* L. Scarce in woods.

436. *C. punctata* Jacq. Abundant in woods.

437. *C. coccinea* L. Scarce in woods.

438. *C. macracantha* Lodd. Scarce in woods. (*C. coccinea macra*
cantha D.)

439. *C. mollis* (T. & G.) Scheele. Abundant in woods and thicket

440. *C. tomentosa* L. Rare in woods.

DRUPACEAE.

PRUNUS.

441. *P. americana* Marsh. Abundant in woods and along roadsides.
442. *P. pennsylvanica* L. f. Plenty in woods.
443. *P. virginiana* L. Abundant in woods and along streams.
444. *P. demissa* (Nutt.) Walp. Rare on prairies.
445. *P. serotina* Ehrh. Abundant in woods.

MIMOSACEAE.

ACUAN.

446. *A. illinoensis* (Michx.) Kuntze. Plenty along streams.

CAESALPINACEAE.

CASSIA.

447. *C. chamaecrista* L. Abundant in sandy soil.

GLEDITSIA.

448. *G. triacanthos* L. Plenty in woods and along streams.

GYMNOCLADUS.

449. *G. dioica* (L.) Koch. Plenty in woods.

PAPILIONACEAE.

BAPTISIA.

450. *B. bracteata* Ell. Abundant in fields and prairies.
451. *B. leucantha* T. & G. Plenty in fields and meadows.

CROTALARIA.

452. *C. sagittalis* L. Scarce in meadows.

MEDICAGO.

453. *M. sativa* L. Plenty; escaped and thriving.

MELILOTUS.

454. *M. alba* Desv. Very abundant along roadside, a very troublesome plant. Has overrun the country within the last few years.
455. *M. officinalis* (L.) Lam. Scarce but spreading.

TRIFOLIUM.

456. *T. aureum* Poll. Scarce in dry soil. (*T. agrarium* L., In part.)
457. *T. procumbens* L. Rather scarce.
458. *T. pratense* L. Abundant.
459. *T. hybridum* L. Abundant in fields and meadows.
460. *T. repens* L. Abundant in fields and meadows.

PSORALEA.

461. *P. argophylla* Pursh. Abundant on prairies.
462. *P. esculenta* Pursh. Plenty on prairies.

AMORPHA.

463. *A. canescens* Pursh. Abundant on prairies.
464. *A. fruticosa* L. Common along streams.
465. *A. nana* Nutt. Nearly extinct, formerly common on prairies.

PAROSELLA.

466. *P. dalea* (L.) Britton. Rare, adventive.

KUHNISTERA.

467. *K. candida* (Wild.) Kuntze. Abundant in meadows. (*Petalostemon candidus* Michx.)

468. *K. purpurea* (Vent.) MacM. Abundant in meadows. (*Petalostemon violaceus* Michx.)

ROBINIA.

469. *R. pseudacacia* L. Scarce in woods and escaped from cultivation

ASTRAGALUS.

470. *A. crassicarpus* Nutt. Abundant on prairies.

471. *A. carolinianus* L. Plenty.

GLYCYRRHIZA.

472. *G. lepidota* Pursh. Plenty in moist soil.

MEIBOMIA.

473. *M. grandiflora* (Walt.) Kuntze. Plenty in woods. (*Desmodium acuminatum* D. C.)

474. *M. sessilifolia* (Torr.) Kuntze. Scarce. (*D. sessilifolium* T. & G.)

475. *M. longifolia* (T. & G.) Vail. In woods and on prairies. (*D. canadense longifolium* T. & G.)

476. *M. illinoensis* (A. Gray) Kuntze. Scarce on prairies. (*D. illinoense* A. Gray.)

477. *M. canadensis* (L.) Kuntze. Abundant in thickets and on prairies. (*D. canadense* DC.)

LESPEDEZA.

478. *L. violacea* (L.) Pers. Rare in dry stony soil.

479. *L. hirta* (L.) Ell. Scarce on dry prairies.

480. *L. capitata* Michx. Abundant on prairies.

VICIA.

481. *V. americana* Muhl. Common in fields and meadows.

482. *V. linearis* (Nutt.) Greene. Rare in meadows.

483. *V. caroliniana* Walt. Plenty on prairie hillsides.

LATHYRUS.

484. *L. venosus* Muhl. Abundant.

485. *L. palustris* L. Scarce in moist meadows.

486. *L. decaphyllus* Pursh. Plenty in moist soil.

487. *L. ochroleucus* Hook. Rather rare in woods.

FALCATA.

488. *F. comosa* (L.) Kuntze. Abundant in swamps.

489. *F. pitcheri* T. & G. Occasional in swamps.

APIOS.

490. *A. apios* (L.) MacM. Abundant in swamps.

GALACTIA.

491. *G. volubilis* (L) Britton. Rare in fields.

STROPHOSTYLES.

492. *S. helvola* (L.) Britton. Abundant in sandy soil.

493. *S. pauciflora* (Benth.) S. Wats. Rare in sandy soil.

GERANIACEAE.

GERANIUM.

494. *G. maculatum* L. Scarce, formerly plenty in woods.
495. *G. rotundifolium* L. Rare. Very rare in Iowa.

OXALIDACEAE.

OXALIS.

496. *O. violacea* L. Abundant. Often with white flowers.
497. *O. stricta* L. Abundant everywhere.
498. *O. cymosa* Small. Scarce in woods.

LINACEAE.

LINUM.

499. *L. usitatissimum* L. Sparingly escaped from cultivation.
500. *L. sulcatum* Riddell. Common on prairies.

RUTACEAE.

XANTHOXYLUM.

501. *X. americanum* Mill. Abundant in woods.

PTELEA.

502. *P. trifoliata* L. Plenty in woods.

POLYGALACEAE.

POLYGALA.

503. *P. verticillata* L. Common in meadows.
504. *P. viridescens* L. Scarce in meadows.
505. *P. senega* L. Scarce in rocky woods.

EUPHORBIACEAE.

ACALYPHA.

506. *A. virginica* L. Abundant in woods.

EUPHORBIA.

507. *E. serpyllifolia* Pers. Scarce.
508. *E. glyptosperma* Engelm. Scarce.
509. *E. nutans* Lag.
510. *E. corollata* L. Abundant on prairies.
511. *E. maculata* L. Abundant in fields and gardens.
512. *E. dentata* Michx. Scarce in waste places.
513. *E. heterophylla* L. Common in waste places.
514. *E. obtusata* Pursh. Scarce in dry soil.
515. *E. missouriensis* (Norton) Small. Scarce in sandy soil. (E. *dichotosperma* of Britton and Brown's Illustrated Flora but not of F. & M.)
516. *E. cyparissias* L. Common; escaped from gardens.

ANACARDACEAE.

RHUS.

517. *R. glabra* L. Common in woods.

518 *R. radicans* L. Common in woods and spreading to fields.

CELASTRACEAE.

EUONYMUS.

519. *E. atropurpureus* Jacq. Plenty in woods and along streams.

CELASTRUS.

520. *C. scandens* L. Common in woods and along streams.

STAPHYLEACEAE.

STAPHYLEA.

521. *S. trifolia* L. Plenty in woods.

ACERACEAE.

ACER.

522. *A. saccharinum* L. Common in woods.
523. *A. saccharum* Marsh. Scarce in woods.
524. *A. nigrum* Michx. Common in woods.
525. *A. negundo* L. Common.

HIPPOCASTANACEAE.

AESCULUS.

526. *A. octandra* Marsh. Plenty in woods.

BALSAMINACEAE.

IMPATIENS.

527. *I. biflora* Walt. Abundant in swamps and marshes.
(I. *fulva* Nutt.)

528. *I. aurea* Muhl. Similar situations and nearly as abundant.
(I. *pallida* Nutt.)

RHAMNACEAE.

CEANOTHUS.

529. *C. americanus* L. Abundant on prairies.
530. *C. ovatus pubescens* T. & G. Scarce on stony hillsides.

VITACEAE.

VITIS.

531. *V. vulpina* L. Common along streams.
532. *V. palmata* Vahl. Rather rare in woods.

PARTHENOCISSUS.

533. *P. quinquefolia* (L) Planch. Abundant in woods. (*Ampelopsis quinquefolia* Michx.)

TILIACEAE.

TILIA.

534. *T. Americana* L. Abundant in woods.

MALVACEAE.

MALVA.

535. *M. rotundifolia* L. Abundant in waste places.

CALLIRRHOE.

536. *C. triangulata* (Leavenw.) A. Gray. Rare. One colony along a railway right-of-way. Flowers very light for this species.
537. *C. involucrata* (T. & G.) A. Gray. Rare on dry prairie.

ABUTILON.

538. *A. abutilon* (L.) Abundant in fields and waste places. (*A. avicennae* Goertn.)

HIBISCUS.

539. *H. trionum* L. Plenty in fields and waste places.

HYPERICACEAE.

HYPERICUM.

540. *H. ascyron* L. Scarce along streams.
541. *H. mutilum* L. Abundant in moist soil.

CISTACEAE.

HELIANTHEMUM..

542. *H. majus* (L.) B. S. P. Common on prairie hillsides.
543. *H. canadense* (L.) Michx. Rare in sandy soil.

LECHEA.

544. *L. tenuifolia* Michx. Rare in stony soil.

VIOLACEAE.

VIOLA.

545. *V. palmata* L. Abundant in open woods.
546. *V. pedatifida* Don. Commcn on prairies.
547. *V. pedata* L. Not so common; sandy hillsides.
548. *V. obliqua* Hill. Common on prairies and in woods. (*V. cucullata* Ait. V. *affinis* LeConte.)
549. *V. papilionacea* Pursh. Scarce in woods and meadows.
550. *V. pubescens* Ait. Common in rich woods. Some forms are near V. *scabriuscula* (T. & G.) Schwein.

THYMELEACEAE.

DIRCA.

551. *D. palustris* L. Rare in rocky woods.

LYTHRACEAE.

LYTHRUM.

552. *L. alatum* Pursh. Abundant in swampy soil.

ONAGRACEAE.

LUDWIGIA.

553. *L. polycarpa* Short & Peter. Scarce in swamps and marshes. A very peculiar procumbent form is found here rarely, which does not agree with the generic characteristic of "erect" plants.

EPILOBIUM.

554. *E. lineare* Muhl. Plenty in swamps.
555. *E. coloratum* Muhl. Plenty in swamps.
556. *E. adenocaulon* Haussk. Scarcer, along streams.

ONAGRA.

557. *O. biennis* (L) Scop. Common in meadows.

MERIOLIX.

558. *M. serrulata* (Natt.) Walp. Abundant on prairit hillsides.

CIRCAEA.

559. *C. Lutetiana* L. Abundant in rich woods.

HALORAGIDACEAE.

MYRIOPHYLLUM.

560. *M. spicatum* L. Common in swamps.
561. *M. verticillatum* L. Scarce in swamps.

ARALIACEAE.

ARALIA.

562. *A. racemosa* L. Common in woods.
563. *A. nudicaulis* L. Plenty in woods.

PANAX.

564. *P. quinquefolium* L. Scarce in rich woods. Formerly common. (*Aralia quinquefolia* Dec. *Ginseng quinquefolium* Wood.)

UMBELLIFERAE.

SANICULA.

565. *S. marylandica* L. Abundant in woods.
566. *S. gregaria* Bicknell. Scarce in woods.
567. *S. trifoliata* Bicknell. Rare in woods.
568. *S. canadensis* L. Scarce in woods.

ERYNGIUM.

569. *E. aquaticum* L. Common in moist meadows. (*E. yuccaefolium* Michx.)

WASHINGTONIA (OSMORRHIZA Raf.)

570. *W. claytoni* (Michx.) Britton. Abundant in woods.
571. *W. longistylis* (Torr.) Britton. Scarce in woods.

ZIZIA.
572. *Z. aurea* (L.) Koch. Common in fields and meadows.
CICUTA.
573. *C. maculata* L. Scarce in marshy places.
574. *C. bulbifera* L. Scarce in marshy places.
DERINGA.
575. *canadensis* (L.) Kuntze. Abundant in rich woods. (*Cryptotaenia canadensis* DC.)
CARUM
576. *C. carui* L. Scarce; escaped from gardens.
TAENIDIA.
577. *T. integerrima* (L.) Drude. Abundant. (*Pimpinella integerrima* A. Gray.)
SIUM.
578. *S. cicutaefolium* Gmel. Rather scarce in wet places.
THASPIUM.
579. *T. barbinode* (Michx.) Nutt. Plenty in woods.
PASTINACA.
580. *P. sativa* L. Plenty in fields and waste places.
HERACLEUM.
581. *H. lanatum* Michx. Scarce in moist places.
DAUCUS.
582. *D. pussilus* Michx. Very rare in high sandy fields.

CORNACEAE.

CORNUS.
583. *C. circinata* L'Her. Abundant in woods and along streams.
584. *C. amomum* Mill. Scarce in damp places.
585. *C. stolonifera* Michx. Rather scarce in moist soil.
586. *C. candidissima* Marsh. Very common in woods and along roads. (C. *paniculata* L'Her.)
587. *C. alternifolia* L. f. Scarce in rocky woods.

MONOTROPACEAE.

MONOTROPA.
588. *M. uniflora* L. Rare in deep woods. Commonly called "Corpse-plant" from its changing from waxy white to black when picked.

PRIMULACEAE.

LYSIMACHIA.
589. *L. quadrifolia* L. Scarce in open woods.
STEIRONEMA.
590. *S. ciliatum* (L.) Raf. Abundant in moist soil.
591. *S. lanceolatum* (Walt.) A. Gray. Rare in wet places.
592. *S. quadriflorum* (Sims.) Hitchc. Abundant in moist fields.
NAUMBURGIA.
593. *N. thyrsiflora* (L.) Duby. Plenty in swamps and marshes. (*Lysimachia thyrsiflora* L.)

OLEACEAE.

FRAXINUS.

594. *F. americana* L. Plenty in woods.
595. *F. lanceolata* Borck. Common in deep woods.
596. *F. nigra* Marsh. Plenty in moist woods.

GENTIANACEAE.

GENTIANA.

597. *G. puberula* Michx. Plenty on prairie hillsides.
598. *G. andrewsii* Griseb. Abundant in swamps and marshes.
599. *G. flavida* A. Gray. Plenty in moist thickets.
600. *G. rubricaulis* Schwein. Scarce in moist soil.

MENYANTHACEAE.

MENYANTHES.

601. *M. trifoliata* L. Scarce in swamps.

APOCYNACEAE.

APOCYNUM.

602. *A. androsaemifolium* L. Abundant in fields and woods.
603. *A. cannabinum* L. Very abundant in fields and waste places.
604. *A. hypericifolium* Ait. Rather scarce in dry soil.

ASCLEPIADACEAE.

ASCLEPIAS.

605. *A. tuberosa* L. Common on prairies. "Pleurisy-root".
606. *A. purpurascens* L. Scarce in woods.
607. *A. incarnata* L. Common in swamps.
608. *A. sullivantii* Engelm. Rare in open fields.
609. *A. syriaca* L. Common in fields and waste places. (*A. cornuti* Dec.)
610. *A. ovalifolia* Dec. Scarce in dry soil.
611. *A. verticillata* L. Common on prairies and in waste places.

ACERATES.

612. *A. viridiflora* (Raf.) Eaton. Common on dry prairies.
613. *A. lanuginosa* (Nutt.) Dec. Scarce on dry prairies.

CONVOLVULACEAE.

IPOMOEA.

614. *I. purpurea* (L). Roth. Plenty; escaped from gardens.

CONVOLVULUS.

615. *C. sepium* L. Abundant in fields and along streams.
616. *C. arvensis* L. Scarce in dry fields.

CUSCUTACEAE.

CUSCUTA.

617. *C. arvensis* Beyrich. On *Solidago serotina*. Rare.
618. *C. polygonorum* Engelm. Plenty on Polygonaceae.
619. *C. paradoxa* Raf. Common on Compositae. Distinguished from our other species by the thick flower clusters. (*C. glomerata* Choisy. *C. aphylla* Raf.)

POLEMONIACEAE.

PHLOX.

620. *P. glaberrima* L. Rare in open woods.

621. *P. pilosa* L. Abundant in meadows.

622. *P. divaricata* L. Abundant in woods.

HYDROPHYLLACEAE.

HYDROPHYLLUM.

623. *H. virginicum* L. Common in moist woods.

624. *H. appendiculatum* Michx. Plenty in rich woods. (*Ellisia* L.)

MACROCALYX

625. *M. nyctelea* (L.) Kuntze. Abundant in moist soil.

BORAGINACEAE.

CYNOGLOSSUM.

626. *C. officinale* L. Common in waste places.

LAPPULA.

627. *L. lappula* (L.) Karst. Common in waste places. Spreading. (*Echinospermum lappula* Lehm.)

628. *L. virginiana* (L.) Greene. Common in dry woods. (*E. virginicum* Lehm.)

629. *L. americana* (A. Gray) Rydb. Scarce in thickets. (*E. deflexum Var Americanum* A. Gray.)

AMSINCKIA.

630. *A. spectabilis* F. & M. Very rare in waste places; adventive. Identification verified by Prof. Aven Nelson, Univ., Wyo.

LITHOSPERMUM.

631. *L. latifolium* Michx. Plenty in woods.

632. *L. canescens* (Michx.) Lehm. Abundant on dry prairies.

633. *L. linearifolium* Goldie. Plenty in dry sandy soil. (*L. angustifolium* Michx.)

ONOSMODIUM.

634. *O. carolinianum* (Lam.) DC. Common on prairies.

635. *O. molle* Michx. Plenty on prairies.

VERBENACEAE.

VERBENA.

636. *V. urticifolia* L. Common in woods and fields.

637. *V. hastata* L. Abundant in fields.

638. *V. hastata pinnatifida* (Lam.) Britton. Scarce on prairies.

639. *V. stricta* Vent. Abundant on prairies. This and the above three species hybridize freely producing puzzling forms.

640. *V. bracteosa* Michx. Plenty in dry fields and waste places.

LIPPIA.

641. *L. lanceolata* Michx. Scarce in swamps.

LABIATAE.

TEUCRIUM.

642. *T. occidentale* A. Gray. Common in swampy places.

SCUTELLARIA.

643. *S. lateriflora* L. Common along streams.

644. *S. parvula* Michx. Plenty in swampy places.

645. *S. galericulata* L. Scarce in swampy places.

AGASTACHE.

646. *A. nepetoides.* (L.) Kuntze. Scarce in woods. (*Lophanthus nepetoides* Benth.)

647. *A. scrophulariaefolia* (Willd.) Kuntze. Common in woods. (*L. scrophulariaefolius* Benth.)

NEPETA.

648. *N. cataria* L. Common in woods and waste places.

GLECOMA.

649. *G. hederacea* L. Plenty in waste places.

PRUNELLA.

650. *P. vulgaris* L. Very abundant in woods and fields.

PHYSOSTEGIA.

651. *P. virginiana* (L.) Benth. Plenty in moist places.

LEONURUS.

652. *L. cardiaca* L. Plenty in woods and waste places.

STACHYS.

653. *S. ambigua* (A. Gray) Britton. Rare in moist places.

654. *S. palustris* L. Abundant in swampy places.

655. *S. tenuifolia* Willd. Rare in moist thickets.

MONARDA.

656. *M. fistulosa* L. Abundant in fields.

HEDEOMA.

657. *H. pulegioides* (L.) Pers. Rare. In dry soil.

658. *H. hispida* Pursh. Abundant in sandy soil.

KOELLIA.

659. *K. flexuosa* (Walt.) MacM. Plenty in woods and fields. (*Pycnanthemum linifolium* Pursh.)

660. *K. virginiana* (L.) MacM. Abundant in woods and fields. (*P. lanceolatum* Pursh.)

LYCOPUS.

661. *L. virginicus* L. Plenty in swamps.

662. *L. americanus* Muhl. Common in marshy places. (*L. sinuatus* Ell.)

663. *L. lucidus* Turcz. Scarce in marshy places.

MENTHA.

664. *M. canadensis* L. Common in swampy places.

SOLANACEAE.

PHYSALIS.

665. *P. pruinosa* L. Scarce in waste places.

666. *P. philadelphica* Lam. Common in dry soil.

667. *P. lanceolata* Michx. Plenty on prairies.

668. *P. virginiana* Mill. Scarce in dry soil. (*P. lanceolata* Roem. Not of Michx.)

669. *P. comata* Rydb. Scarce on prairie hillsides.

SOLANUM.

670. *S. nigrum* L. Abundant in waste places.

671. *S. rostratum* Dunal. Rare in waste places.

DATURA.

672. *D. stramonium* L. Scarce in waste places.

673. *D. tatula* L. Scarce in waste places.

SCROPHULARIACEAE.

VERBASCUM.

674. *V. thapsus* L. Abundant in fields and waste places.

LINARIA.

675. *L. linaria* (L) Karst. Scarce in waste places. Adventive.

SCROPHULARIA.

676. *S. marylandica* L. Abundant in woods and along streams. (*S. nodosa var marylandica* A. Gray.)

677. *S. leporella* Bicknell. Less common and in similar localities.

MIMULUS.

678. *M. ringens* L. Abundant along streams and in swampy places.

GRATIOLA.

679. *G. virginiana* L. Scarce in wet places.

ILYSANTHES.

680. *I. dubia* (L.) Barnh. Scarce in wet places. (*I. gratioloides* (L.) Benth.)

VERONICA.

681. *V. anagallis-aquatica* L. Scarce in marshy soil.

682. *V. peregrina* L. Common in marshy soil.

LEPTANDRA.

683. *L. virginica* (L) Nutt. Abundant in woods and meadows. (*Veronica virginica* L.)

GERARDIA.

684. *G. purpurea* L. Rare in moist meadows.

685. *G. paupercula* (A. Gray) Britton. Prairies, quite common.

686. *G. besseyana* Britton. Abundant on prairies and in open woods.

687. *G. auriculata* Michx. Plenty in waste places.

CASTILLEJA.

688. *C. sessiliflora* Pursh. Scarce on high prairies.

PEDICULARIS.

689. *P. lanceolata* Michx. Common in swamps.

690. *P. canadensis* L. Abundant. Most descriptions give the habitat of this species as "Dry woods and thickets" but ours is more common in moist meadows and even in swampy places.

LENTIBULARIACEAE.

UTRICULARIA.

691. *U. vulgaris* L. Common in swamps.

PHRYMACEAE.

PHRYMA.

692. *P. leptostachya* L. Abundant in woods and thickets.

PLANTAGINACEAE.

PLANTAGO.

693. *P. major* L. Abundant everywhere.

694. *P. rugelii* Dec. Common in fields and woods.

695. *P. lanceolata* L. Scarce in waste places.

696. *P. purshii* R. & S. Plenty on dry prairies.

697. *P. aristata* Michx. Scarce on high prairies.

RUBIACEAE.

GALIUM.

698. *G. aparine* L. Plenty in woods and fields.

699. *G. mollugo* L. Rare. Some doubtful specimens appear to belong here.

700. *G. boreale* L. Common in woods and along streams.

701. *G. tinctorium* L. Common in marshy meadows.

702. *G. concinnum* T. & G. Abundant in rocky woods.

CAPRIFOLIACEAE.

SAMBUCUS.

703. *S. canadensis* L. Common in woods and along streams.

VIBURNUM.

704. *V. pubescens* (Ait.) Pursh. Scarce in rocky woods. (*V. dentatum pubescens* Ait.)

705. *V. lentago* L. Common in thickets and along roadsides.

TRIOSTEUM.

706. *T. perfoliatum* L. Scarce in low woods.

707. *T. aurantiacum* Bicknell. More common in rich woods.

SYMPHORICARPUS.

708. *S. racemosus* Michx. Abundant in woods and on rock banks of streams.

709. *S. occidentalis* Hook. Scarce in thickets.

LONICERA.

710. *L. glaucescens* Rydb. Plenty in woods. (*L. douglasii* Lind.)

711. *L. dioica* L. Plenty in woods.

DIERVILLA.

712. *D. diervilla* (L) MacM. Rare in rocky woods.

CUCURBITACEAE.

MICRAMPELIS.

713. *M. lobata* (Michx.) Greene. Abundant in thickets and along streams. (*Echinocystis lobata* T. & G.)

SICYOS.

714. *S. angulatus* L. Rare in woods.

CAMPANULACEAE.

CAMPANULA.

715. *C. rotundifolia* L. Plenty in rocky places. The rotund base leaves usually very inconspicuous.

716. *C. aparinoides* Pursh. Plenty in swamps and marshes. Flowers mostly white.

717. *C. americana* L. Abundant in thickets and along streams.

SPECULARIA.

718. *S. perfoliata* (L.) A. DC. Plenty in woods and rarely on open prairie.

LOBELIA.

719. *L. syphilitica* L. Abundant in moist soil.

720. *L. spicata* Lam. Abundant in fields and meadows.

721. *L. leptostachys* A. DC. Scarcer in dry meadows.

CICHORIACEAE.

CICHORIUM.

722. *C. intybus* L. Scarce in thickets and waste places.

TRAGOPOGON.

723. *T. pratensis* L. Rare in waste places.

724. *T. porrifolius* L. Scarce in waste places. Escaped from cultivation.

TARAXACUM.

725. *T. taraxacum* (L.) Karst. Abundant everywhere. (*T. dens leonis* Desf.)

726. *T. erythrospermum* Andrez. Scarcer but not rare.

SONCHUS.

727. *S. oleraceus* L. Common in fields and waste places.

728. *S. asper* (L.) All. Plenty in waste places.

LACTUCA.

729. *L. scariola* L. Abundant as a weed in fields and in waste places.

730. *L. canadensis* L. Scarce in moist soil.

731. *L. ludoviciana* (Nutt.) DC. Scarce in waste places.

732. *L. floridana* (L.) Gaertn. In moist soil. Sometimes 10 feet high.

LYGODESMIA.

733. *L. juncea* (Pursh.) D. Don. Rare on high prairies

NOTHOCALAIS.

734. *N. cuspidata* (Pursh.) Greene. Abundant on prairie hillsides.

HIERACIUM.

735. *H. canadense* Michx. Scarce in dry woods.

NABALUS.

736. *N. albus* (L.) Hook. Abundant in woods. (*Prenanthes alba* L.)

737. *N. asper* (Michx. T. & G.) Plenty on dry prairies. (*Prenanthes aspera* Michx.)

738. *N. racemosus* (Michx.) DC. Scarce along edges of woods and on open prairie. (P. *racemosa* Michx.)

AMBROSIACEAE.

IVA.

739. *I. xanthifolia* (Fresen.) Nutt. Common in swampy fields.

AMBROSIA.

740. *A. trifida* L. Plenty in fields and waste places.

741. *A. trifida integrifolia* (Muhl.) T. & G. Scarcer; with the above.

742. *A. artemisiaefolia* L. A common and troublesome weed everywhere.

743. *A. psilostachya* DC. Rather scarce on dry prairies.

XANTHIUM.

744. *X. canadense* Mill. Common in waste places.

COMPOSITAE.

VERNONIA.

745. *V. fasciculata* Michx. Abundant in moist places.

EUPATORIUM.

746. *E. maculatum* L. Common in swamps and marshes.
747. *E. purpureum* L. Common in open woods and thickets.
748. *E. altissimum* L. Plenty in sandy soil.
749. *E. perfoliatum* L. Very abundant in swampy places.
750. *E. ageratoides* L. f. Common in open woods.

KUHNIA.

751. *K. eupatorioides* L. Scarce on dry prairies.
752. *K. glutinosa* Ell. Common in dry soil.

LACINARIA.

753. *L. squarrosa* (L.) Hill. Scarce on prairies. (*Liatris squarrosa* Willd.)
754. *L. punctata* (Hook.) Kuntze. Common on prairie hillsides. (*Liatris punctata* Hook.)
755. *L. acidota* (Engelm. & Gray) Kuntze. Very rare. This western species has been found here on two occasions; along the right of way of a railway in both cases.
756. *L. pycnostachya* (Michx.) Kuntze. Abundant on prairies.
757. *L. scariosa* (L.) Hill. Plenty on prairies.

SOLIDAGO.

758. *S. caesia* L. Rare in woods and thickets.
759. *S. flexicaulis* L. Plenty in woods and thickets.
760. *S. hispida* Muhl. Scarce in rocky woods.
761. *S. rigidiuscula* (T. & G.) Porter. Common on prairie hillsides.
762. *S. rugosa* Mill. Scarce along edges of woods.
763. *S. ulmifolia* Muhl. Common in woods and thickets.
764. *S. rupestris* Raf. Scarce in rocky woodlands.
765. *S. serotina* Ait. Plenty in woods and prairies.
766. *S. missouriensis* Nutt. Scarce on prairie hillsides.
767. *S. canadensis* L. Abundant in fields and woods. Possibly one or more of the listed varieties also occur.
768. *S. nemoralis* Ait. Common on dry prairies.
769. *S. mollis* Bartl. Scarce on high prairies.
770. *S. rigida* L. Common on prairies.
771. *S. riddellii* Frank. Plenty in most fields.

EUTHAMIA.

772. *E. graminifolia* (L.) Nutt. Plenty in moist fields.

BOLTONIA.

773. *B. asteroides* (L.) L'Her. Abundant in moist fields.

ASTER.

774. *A. azureus* Lindl. Plenty on prairies.
776. *A. drummondii* Lindl. Very rare in woods.
776. *A. Drummondii* Lindl. Very rare in woods.
777. *A. phlogifolius* Muhl. Some specimens from a moist woodland which were found in '04, but not noted since.
778. *A. novae-angliae* L. Abundant in fields, swamps and thickets.
779. *A. oblongifolius* Nutt Plenty on prairie hillsides.
780. *A. amethystinus* Nutt. Abundant on prairies.

781. *A. prenanthoides* Muhl. Rare in rocky woods. Found in one locality only.
782. *A. laevis* L. Abundant in woods and fields.
783. *A. concinnus* Willd. Rarely on prairies.
784. *A. sericeus* Vent. Common on prairie hillsides.
785. *A. dumosus* L. Rare in dry soil.
786. *A. salicifolius* Lam. Common on high prairies.
786½. *A. paniculatus* Lam. Abundant in fields.
787. *A. paniculatus simplex* (Willd.) Burgess. Plenty in moist places.
788. *A. tradescanti* L. Plenty in fields and meadows.
789. *A. ericoides* L. Rather scarce on prairies.
790. *A. lateriflorus* (L.) Britton. Scarce in fields and along edges of
791. *A. hirsuticaulis* Lindl. Very rare in open woods.
792. *A. multiflorus* Ait. Abundant in woods and on prairies. woodlands and thickets.

ERIGERON.

793. *E. philadelphicus* L. Plenty in fields and woods.
794. *E. annuus* (L.) Pers. Common in fields and meadows.
795. *E. ramosus* (Walt.) B. S. P. Abundant in fields and meadows.

LEPTILON.

796. *L. canadense* (L.) Britton. Very abundant everywhere.
797. *L. divaricatum* (Michx.) Raf. Scarce along streams.

DOLLINGERIA.

798. *D. umbellata* (Mill.) Nees. Scarce in marshes.

ANTENNARIA.

799. *A. campestris* (Rydb.) Scarce on prairies.
800. *A. plantaginifolia* (L.) Richards. Abundant not only in woods but also in open places.

SILPHIUM.

801. *S. perfoliatum* L. Common in fields and meadows.
802. *S. laciniatum* L. Common in fields and meadows.

HELIOPSIS.

803. *H. scabra* Dunal. Abundant in fields and along roadsides.

RUDBECKIA.

804. *R. triloba* L. Common in woods and moist fields.
805. *R. hirta* L. Abundant in woods and fields.
806. *R. subtomentosa* Pursh. Rare on open prairie.
807. *R. laciniata* L. Plenty in the thickets.

RATIBIDA.

808. *R. pinnata* (Vent.) Barnh. Common on prairies.
809. *R. columnaris* (Sims) D. Don. Rare in dry soil.

BRAUNERIA.

810. *B. angustifolia* (DC.) Heller. Plenty in dry soil.
811. *B. pallida* (Nutt.) Britton. Common on prairies.

HELIANTHUS.

812. *H. annuus* L. Plenty in waste places.
813. *H. scaberrimus* Ell. Common in dry soil.
814. *H. maximiliani* Schrad. Rather scarce in dry soil.

815. *H. grosse-serratus* Martens. Common on prairies and along streams.
816. *H. decapetalus* L. Scarce along streams.
817. *H. tuberosus* L. Scarce in moist soil.

CORKOPSIS.
818. *C. palmata* Nutt. Abundant on prairies.

BIDENS.
819. *B. laevis* (L.) B. S. P. Scarce in fields and meadows.
820. *B. cernua* L. Plenty in waste places.
821. *B. connata* Muhl. Scarce in moist soil.
822. *B. comosa* (A. Gray) Wiegand. Scarce in moist soil.
823. *B. frondosa* L. Abundant in fields and woods.
824. *B. trichosperma tenuiloba* (A. Gray) Britton. Rare. Adventive.
825. *B. involucrata* (Nutt.) Britton. Scarce in swamps.

GALINSOGA.
826. *G. parviflora* Cav. Rare in waste places.

HELENIUM.
827. *H. autumnale* L. Abundant in fields and swamps.

BOEBERA.
828. *B. papposa* (Vent.) Rydb. Common in waste places. (*Dysodia papposa* (Vent.) A. S. Hitchc.)

ACHILLEA.
829. *A. lanulosa* Nutt. Abundant on prairies.
830. *A. millefolium* L. Less common and usually in the pink flowered form.

ANTHEMIS.
831. *A. cotula* L. Common in waste places and along roadsides.
832. *A. arvensis* L. Scarce in fields.

TANACETUM.
833. *T. vulgare* L. Common, usually escaped from gardens.

ARTEMISIA.
834. *A. caudata* Michx. Common in sandy soil.
835. *A. canadensis* Michx. Rare, adventive.
836. *A. dracunculoides.* Pursh. Plenty in dry soil.
837. *A. biennis* Willd. Plenty on prairies.
838. *A. serrata* Nutt. Scarce on prairies.
839. *A. longifolia* Nutt. Plenty on prairie hillsides.
840. *A. gnaphalodes* Nutt. Abundant on dry prairies.

ERECHTITES.
841. *E. hieracifolia* (L.) Raf. Plenty in woods and thickets.

MESADENIA.
842. *M. tuberosa* (Nutt.) Britton. Abundant in moist fields and meadows.

SENECIO.
843. *S. balsamitae* Muhl. Plenty in sandy soil.
844. *S. aureus* L. Common in swamps and fields.
845. *S. palustris* (L.) Hook. Rare in swamps and marshes.

ARCTIUM.
846. *A. lappa* L. Abundant in woods and waste places.
847. *A. minus* Schk. Rare in waste places.

CARDUUS.
848. *C. lanceolatus* L. Abundant in fields and waste places.
849. *C. altissimus* L. Plenty in woods and fields.
850. *C. discolor* (Muhl.) Nutt. Common in fields.
851. *C. arvenis* (L.) Robs. Plenty in fields and waste places.
852. *C. ioense* Pammel. Scarce on prairies.

FLORISTIC NOTES FROM AN ILLINOIS ESKER.

BY BRUCE FINK.

Plates IV-VI.

Kaneville is a village in Kane county, Illinois, and is situated about fourteen miles from Aurora, Illinois, west by a few degrees north. At Kaneville, the present writer passed several years of his boyhood and early youth, and here it was that he took his first lessons in natural science, learning the names and habits of a considerable number of birds and plants and gaining some inklings of the interesting mysteries of geological science.

Northeast of Kaneville, some seven miles, is located the conspicuous elevation, standing some 80 feet above the surrounding country, covering about 100 acres, and known as Bald Mound. About two miles from Bald Mound, in the direction of Elburn, lies the similar but wooded swell of land known as Johnson's Mound. Passing two or three miles southeast of Kaneville, on the Aurora road, one finds at the right of the road a rounded hill, near the yard formerly known as the "Billy Benton" place, but now owned by Clarence Humiston. This hill rises to an elevation of about 40 feet above the surrounding prairie and is a conspicuous landmark. Passing in the direction of Aurora, one soon notices on the opposite side of the road a long gravel hill, of similar elevation, at first a mile wide and tumultuously irregular, but soon becoming regular and narrow, with a rounded top only two or three rods across and sloping downward at an angle of about thirty degrees with the horizon.

These gravel hills and many other similar ones in this portion of Illinois were among the unsolved mysteries of youthful days, and the summer of 1905 gave the writer the first opportunity, since having had some experience in interpreting topographic features and observing the accompanying plant life, of studying the familiar till knolls and the esker with their flora.

The rounded hill at the Humiston place, and the long hill into which it is continued are a portion of the "Kaneville Esker",—the bed of an extinct subglacial stream. This esker has been traced from a point three or four miles northwest of Aurora, to the rounded hill noted above and is about eight miles long. Toward Aurora erosion has planed the esker down until at present it consists of a series of knolls and short ridges, but further northwestward one finds toward the Kanesville-ward end of the esker a continuous ridge, from 20 to 60 feet high, with only occasional gaps, and slopes frequently as high as 30 degrees. Still northwestward from the esker proper, which terminates at the rounded hill, lies the delta of the old subglacial river, covering an area of about eight square miles, surrounding the village of

Kaneville, and rising a few feet above the till plain of the region. Well borings in the delta region have shown a deposit of gravel and sand 30 or 40 feet deep, but most of the area is covered with humus, giving mesophytic conditions and making excellent farm-land, with here and there a surface exposure of gravel, bringing xerophytic conditions and easily available gravel and sand, the largest of these being on the Spenser farm, about a mile from Kaneville.

Bald Mound and Johnson's Mound are but two high elevations of the undulating till sheet left by the glacier (Wisconsin till sheet) and extending at least from Plano, in Kendall county, northward through Sugar Grove and Blackberry townships in Kane county. The esker crosses this area of till knolls in Sugar Grove township, and the general topography of the till area is not greatly different from that of the more tumultuous portion of the esker, so that the casual observer would find it difficult to distinguish between this portion of the esker and the general till-topography.

The esker and the till knolls are quite similar as to nature of deposit, all containing gravel, with beds of sand and clay interspersed, and all form the main deposit, running and percolating water carrying the finer portions down to a lower level. As the writer traveled over portions of this area last summer, he was impressed with the former possibility of an excellent ecologic study, but pasturing, deforestation, and cultivation have now gone on to such an extent as to leave only a few spots in their original condition, while the gravel is of great value for commercial purposes, and the esker was being removed rapidly while we were studying its flora. The accompanying map shows the position of the esker, the esker valley and the distribution of the till knolls in the surrounding region. To explain further the origin of the till and the esker is too far removed from the present purpose, but those interested are referred to a paper by Frank Leverett, "The Illinois Glacial Lobe", in Monograph 38 of the United States Geological Survey.

Dr. H. C. Cowles, of Chicago University, was with the writer during the first day's study of the flora, and aided considerably in the study of the spermaphytes. The elevation and the gravelly and calcareous nature of the knolls and the esker were found to have resulted in certain floristic peculiarities, purely xerophytic so far as the seed plants are concerned, but both xerophytic and calcareous as regards the lichens. On the rounded hill we found various xerophytic seed-plants and lichens, while the conspicuous fringe of blue vervain (*Verbena stricta*) extending half way up its slope on the north and east, the fringe showing a well-marked zonal arrangement and becoming very thin and appearing at a lower level on the south and southwest sides, the direct rays of the sun and the dry southwest winds of summer doubtless making the conditions too dry for this semi-xerophytic species (Fig. 1). The esker, at the point studied, back of the Dorr residence, extends nearly due east and west, and we found trees fringing the north slope, while the

south slope showed no evidence of having ever been tree-covered, here again the direct rays of the sun having doubtless made it impossible for seedling trees to survive (Fig. 2).

Some of the hills have been pastured, and the pasturing has very largely killed out the earth-lichen societies while the rock-inhabiting species have for most part persisted. In portions of the hill-areas not pastured, there is evidence of a struggle for possession of the dry soil constantly going on between the lichens and the seed plants, and statistical studies extended over a long series of years would bring some exact results, provided a considerable and unmolested area could be studied. Along a portion of the summit of the esker, we found an almost pure formation of *Poa compressa*, with an assemblage of seed-plants among which *Poa pratensis* was conspicuous extending down the slope on either side, while the more xerophytic *Poa compressa* had almost complete possession of the limy soil at the summit in this particular spot, having even largely supplanted the lichens which flourished on the calcareous soil a few rods away. Of course the lichens of the pebbles and limy boulders were persisting successfully, even where *Poa compressa* was thickest.

The conditions at Bald Mound and at Johnson's Mound were very much the same, the former, as the name indicates, being bare of trees, while the greater portion of the latter is well wooded (Fig. 3). The lichen societies of all of these hills are similar to those which the present writer has described from various localities in Iowa and Minnesota, viz. *Lecanora calcarea contorta formations* of calcareous pebbles and *Biatora decipiens formations* of calcareous earth. As in the other areas studied in Iowa and Minnesota, the two lichen formations were found occupying the same areas, those of the soil also as usual competing with other plants, mainly spermaphytes. The lichens of the pebbles and boulders show xerophytic adaptation in scantiness of thallus, and often in hypolithic position and endocarpic fruit conditions and certain minute structural conditions which have been considered by the present writer in extended papers on the lichen flora of Minnesota and need not be repeated in this brief discussion. The lichens of the earth are somewhat larger and have in general good cortices, but are still small lichens, single thalli seldom exceeding four or five millimeters in diameter. Their main structural adaptation lies in the small size and the possession of a good protective cortex. At Johnson's Mound, two specimens of a small *Collema* were found, and in all of the regions a thin, flat, blue-green *Nostoc* colony was common, lying loose on the ground, even in the most xerophytic places at hill tops in pastures. This *Nostoc*, a form of *N. commune* Vauch., has never been seen by the present writer in any of the similar habitats studied elsewhere, and seems quite out of harmony with surroundings, *Nostocs* usually growing in moist places, while a form having a thin, flat colony would be the last one to look for in a dry place. A physiological adaptation of several, or possibly all, of the lichens recorded below is their power of building up fats or oils from the lime of the rocks and the soil.

For the sake of the record of distribution of such lichen societies, it will be worth while to record here the lichens found in the two kinds of societies as follows, the plants occurring in the societies on Bald Mound, on Johnson's Mound, on the esker and on the rounded hills near by, unless otherwise indicated in the list of species below.

LECANORA CALCAREA CONTORTA FORMATIONS.

Verrucaria nigrescens.
Verrucaria muralis.
Verrucaria fuscella.
Placodium vitellinum aurellum, and other species.
Lecanora calcarea contorta.
Biatorella (Lecanora) pruinosa, on Bald Mound only.
Dermatocarpon (Endocarpon) pusillum.
Rinodina bischoffii, not found at Bald Mound.

PSORA DECIPIENS LICHEN FORMATIONS OF EXPOSED CALCAREOUS EARTH.

Endocarpon hepaticum.
Psora (Biatora) decipiens.
Heppia despreauxii, not found at Bald Mound.
Bacidia (Biatora) muscorum, Johnson's Mound and round hill only.

A summary of previous studies of similar lichen formations elsewhere may be found in Minn. Bot. Stud. 2:668-670, My 1901. Comparison of the above lists of species with the data recorded in the above citation shows that the societies studied in Illinois are rather poorer in point of species than the similar ones in Iowa and Minnesota. This is doubtless due in part to the fact that nearly all of the area studied in Illinois had been pastured more or less and also no doubt partly to the fact that the conditions in Illinois are on the whole less xerophytic than those of Iowa and Minnesota. Both of these factors would affect the earth lichens more than those of the rocks, the seed plants occupying the soil more completely in the less xerophytic region so that the lichen societies of the earth are reduced more than those of the rocks, while the pasturing acts in the same way.

The distribution of trees and of *Poa compressa* at the esker has been noticed, and the distribution of trees along both sides of the xerophytic crown of the Johnson's Mound is well shown in Fig. 3, the woods bordering the narrow xerophytic formations on both sides. The full list of xerophytic spermaphytes found on the four hills, and nearly all of them on the esker, is as follows:

Poa compressa.	*Scutellaria parvula.*
Verbena angustifolia.	*Arenaria plantaginifolia.*
Verbena stricta.	*Viola pedata.*
Sysyrinchium sp.	*Erigeron strigosus.*
Andropogon scoparius.	*Petalostemon* sp.
Echinospermum lappula.	*Solidago nemoralis.*
Lithospermum angustifolium.	*Arenaria michauxii.*

The writer has not previously recorded the spermaphytic xerophytes found growing with these lichen societies of the calcareous earth and rocks, and it is through the aid of Dr. Cowles that he is able to do so in this instance. The whole area of the till of the region, as well as the more limited esker would form a most inviting field for extended ecologic study, if indeed natural conditions are not already so much interfered with as to make a complete and exhaustive study impossible.

In closing the writer wishes to express his thanks to Miss Julia Fink for aid in the study, especially in securing the photographs and to Miss Maude Norris for drawing the map, which accompanies this paper.

LICHENS AND RECENT CONCEPTIONS OF SPECIES.

BY BRUCE FINK.

The biological atmosphere is pregnant with ideas regarding species and their evolution. We are brought face to face with the "fluctuation" view of Darwin and the more recent one of "discontinuous variation" of Bateson, later called "fluctuation" by de Vries. Pangenesis has received prominent attention in the discussions regarding evolution; and Weismann formerly thought that germinal selection accounted for all evolution though, in his recent work in two volumes, he admits that conditions of environment may affect the soma when acting continuously through many generations. Another extreme view is that expressed by Jordan in a recent number of "Science", to the effect that isolation plays a part in the evolution of every species. De Vries has not told us that his "mutation theory" accounts for all evolution of species, but he says,—"systemic and physiological facts seem to indicate the existence of universal laws, and it is not probable that the process of production of new species would be different in the various parts of the animal and vegetable kingdoms."

The view expressed by de Vries in the above quotation, as well as the attempt formerly made by Weismann, to account for all evolution through germinal selection, is in accord with the philosophical views of the monist and the pantheist, and since the latter author has now admitted the possibility of environment being a factor in evolution and the former never denied this, both views of evolution seem reasonable enough.

However, when we consider the limited time spent in the observations of de Vries, we may still question whether he has really discovered "elementary species" or merely sports. And furthermore, admitting the validity of his 'elementary" species, we may doubt whether large numbers of "elementary species" will ever be well known and kept in mind long enough for any other use than that of determining the role of mutation in the evolution of species. L. H. Bailey bewails the fact that "we study plastic material; at the same time that we are making a desperate effort * * * toward rigidity of nomenclature". He also tells us that systematists do not distinguish, in describing species, between characters of great and those of small or no physiological value. Apropos of this idea comes the parallelistic view that there can be no morphological evolution of characters without a correlated functional or physiological advance, and the parallelistic view aside, it is generally conceded that, though a structure may begin to appear through hyper-nutrition, it usually soon takes on some function or the hypertrophy simply produces a morphological monstrosity, which soon disappears in phyletic evolution, through atrophy. There seem to be a few

known exceptions such as the adventitious flowers of Nepaul-barley, but it does not appear that the systematist, especially in this day of morphological and physiological enlightenment, is in great danger of taking, for his species marks, any of the few characters that have no physiological significance. Indeed, in the field in which the present writer has done most of his taxonomic work, it is not easy to find a functionless organ or tissue. The spores of higher lichens are thought by many to be functionless or nearly so, but if this be true, they have become so highly developed and characteristic in former stages of phylogenetic development, in which they surely functioned, that they are now important characters in the determination of lichens, and cannot be ignored. The podetia of the Cladonias have doubtless arisen through hypernutrition and, if the spores be functionless, can perform no other function than that of carrying squamules and scredia up into the air where they may be more readily dispersed. Yet we can scarcely see just how the fact of relatively unimportant function would detract from their value as species characters.

In certain recent papers, the binomial nomenclature has been attacked as detrimental to scientific progress and likely to be replaced. The drudgery and uncertainty of matching characters in the herbarium is also bewailed. There is much of reality in all this complaint, and the present writer has had experience enough to know that, in the field of lichenology at least, the worker who has not at different times determined specimens from the same collection as two or more species has had a very limited experience in the work or has been very fortunate in *always* forming the same judgment. Yet the question arises as to how we are ever to know the elementary or biological species among lower plants so that we may replace our often-compound sytematic conceptions. Again, if this ever becomes possible, it may still be doubted whether these biological species will serve any purpose in determinations, or make the work of matching characters any easier. Whatever new plan of classification may be in store for the future, its realization is far enough away, so far as lower plants are concerned, so that we may profitably consider what light all this discussion of morphology and evolution throws on our conception of systematic species.

Those who have followed the recent discussions provoked by de Vries' announcement of the mutation theory cannot have failed to note that it has been confined almost exclusively to higher plants and animals, principally the former. This one sided consideration will never settle the difficult questions involved, and those of us who work on lower plants, where studies similar to those of de Vries on the seed-plants will be much more difficult of carrying to a successful conclusion, may well begin to stir ourselves. There seems to be no doubt that certain phases of the question of evolving of species may be experimented upon by direct observation and cultural methods among algae, fungi and lichens, though in many of these plants, the unit characters must be very obscure and often physiological rather than morphological. Indeed, the work of Falmer on *Agaricus* and certain studies of *Uredineae* point to the possibility of establishing elementary species among fungi, while it is quite

possible that we frequently bring into existence elementary varieties of bacteria and yeast plants partly physiological and partly morphological, by cultivation on various media and by transferring from host to artificial media. The life cycles are often short among lower plants, and this advantage would serve to offset, in part, some other difficulties; and the physiological considerations of relation to substratum, ever becoming of greater and greater importance in the systematic studies of species, may be investigated without great difficulty.

Since the fusion of sexual nuclei has come to be regarded as a potent cause of variation, we may doubt whether rapid evolution may be expected in some of the lower algae and fungi. But in the low unicellular and filamentous forms, division, which corresponds to vegetative reproduction higher up, may bring a form of evolution comparing with bud variation in higher plants. Yet on the whole, we may expect mutation, if such a phenomenon exists among lower plants, to follow the fusion of sexual nuclei more readily than any form of vegetative fusion or vegetative or asexual reproduction. However, recent researches have greatly widened the known range of sexuality among lower plants, so that we may now approach the problem of evolution through sexual fusion among lower plants with more confidence than formerly.

That our views regarding lichen species and varieties are, and always have been, quite crude and often unscientific is apparent enough to one who has attempted to do extended taxonomic work within the group. Many of the names of species date back to Linnaeus' time, when the views regarding species in general were necessarily based upon a very limited amount of observation and were in the main also tainted by the quite prevalent belief in independent creation.

Also with the recent light as to the real nature of the so-called lichen plant, it may well be doubted as to whether we really are at liberty to conceive of any other species than taxonomic, admitted for the sake of expediency in classification. Yet, examining a little closer, it appears to the observer and student of lichen forms that in many instances species or varieties have arisen from a given form since the association of the two symbionts began. Here then, whether we admit with Rienke and Schneider, that a lichen is after all to be regarded as a morphological and physiological unit, we surely seem to have species arising in the usual way, either by fluctuations or by mutations. Thus it appears that, whatever view one may take as to the nature of the lichen, he must treat any discussion of species as though lichens were undoubted autonomies.

But there seems to be at least one very peculiar view as to the lichen-species. And that is the idea entertained by some botanists that lichen species cannot properly be based on morphological characters, since the lichen is not a morphological unit and has not, even as a symbiotic association, acquired any very fixed morphological characters. These botanists, instead of continuing to base our taxonomic lichen-species upon morphological characters, or in part upon physiological relations

as is done in other plants whose morphological characters are not sufficiently differentiated, would have us establish lichen species based upon phylogeny entirely, without any reference to the morphological characters of form, size, color, surface markings, etc. It appears to the present writer that these botanists think of a lichen as a fungus growing upon an alga and therefore irregular and not at all constant in form, much after the manner of a corn-smut outgrowth upon the corn plant, a witches' broom, or some abnormal growth upon some host plant, due to irritation and hyper-nutrition.

But to some of us who have studied the morphological characters of lichens carefully this view seems quite absurd. For, whatever view one may take as to the nature of lichens, careful study demonstrates that the morphological characters of lichens are quite as fixed as those of most undoubted morphological automonies. However, the peculiar views expressed above are suggestive and perhaps worthy of use as a working hypothesis in the study of some lichen species. The present writer would look with great interest to the results that might come from work done in this direction, though he regards the outcome as too hopeless to attempt such studies himself.

But turning to some very different considerations, it appears that many of our so-called taxonomic, lichen species are compound conceptions rather than real species. To the mind of the present writer, even a taxonomic species, used as a basis in classification, should attempt to be a real entity, not a compound idea as is that of family or order. It is well known that the lichenists are not the only people who have had crude ideas as to species, for such compound species are well known even to the workers in spermaphytic taxonomy. But we may eliminate all this from the present discussion, and confine attention to the lichens. Whether we may ever be able to discover real elementary species, in the de Vriesian sense, among such slow-growing plants as the lichens is not certain, but we should at least attempt to bring about a much better taxonomic, working basis.

Instances of bad work in taxonomic outlines of lichen species are not far to seek. There comes to mind, on account of the present writer's recent studies of the genus *Cladonia*, instances from Wainio's "Monographia Cladoniarum Universalis", a work in which one might reasonably expect better results. Witness the so-called species *Cladonia fimbriata*, to which the author devotes more than one hundred pages, giving a multitude of varieties and forms, the specific conception being a compound one, similar to that usually accorded to genera. So far as the present writer knows, no one of these varieties or forms stands out as the prevailing one, so that it could reasonably be called the species. Future world-wide studies may discover this prevailing type, though it may have died out. Again future studies may show that the so-called species should be divided into several. In many other instances, Dr. Wainio has used the same method where there is good evidence that there is a prevailing form, from which the other varieties given have

probably originated in some manner. As instances may be cited *Cladonia coccifera*, where the variety *stemmatina* should stand for the species and *Cladonia pyxidata*, where the variety *neglecta* is the prevailing form from which the other varieties given may have been evolved.

But there is no need of multiplying such instances of bad taxonomic work. We should bring to bear every particle of light the ecologist, the morphologist, the evolutionist, the physiologist and the workers in taxonomy can give us and attempt to bring about a better state of affairs. De Vries has told us that systematists have succeeded in dividing taxonomic species into real elementary species in certain seed-plants, and we may hope to make some progress along this line in lower plants, at least among lichens. In order to do this we need not cast aside all the good methods employed by systematists, and resort to experimental methods solely. Indeed, the method outlined by C. B. Davenport and J. W. Blankinship in a joint paper, "A Precise Criterion of Species," may well be followed. In studying lichens as elsewhere, we describe a new species, not knowing whether it stands at a "center of variation" or not, and only a critical examination of large numbers of individuals will enable us to establish modes (centers of variation), the type specimen frequently not being thus related, but being in reality a variety. We surely need to know for practical working purposes, these centers, the ranges of variation and the degree of isolation. And, though such study may seldom bring us to other than taxonomic species, it is necessary to a study of these and will surely bring our taxonomic species to correspond more nearly with elementary or biological species. We must agree also upon some chief-differentials before we can hope for any stability in taxonomic results. We must likewise as surely cease to place so much stress upon the "historic type", which may not be a true species in any sense, and seek the true "specific type". And it is along the line of such statistical studies as those of Blankinship, Davenport and Weldon that the best results are to be expected. We should approach the study without prejudice as to its relationships to the question of evolution, resting assured that he who has sufficient knowledge of a group of plants to apply statistical methods on a wide scale stands in a fair way to solve some questions extremely vexing to students of taxonomy, at the same time standing good chance of aiding materially in the establishment of many true biological species. This method will also tend to do away with "splitting" and "slumping" without adequate study.

The questions of individual variation, partial variation, progressive evolution, retrogressive evolution, degressive evolution, unit characters, probable mutating species, relative stability or plasticity of species, correlative variations, latency of characters, etc., are all more or less capable of study in lichens and doubtless among other lower plants also.

With the recent researches, tending to establish sexuality among lichens, we may reasonably expect mutations to occur. Yet, this granted,

it is by no means easy to know a lichen generation, while the stimulus and the tendency to vary imparted by fertilization doubtless extends wholly or largely to the fungal symbiont only. Surely the statistical and experimental methods of study of the origin of species may be regarded as a problem within the grasp of mycologists.

Finally, this paper is not to be regarded as anything more than a brief, preliminary setting-forth of some problems which the writer has in mind for future study.

NOTES ON THE DISCOMYCETE FLORA OF IOWA.

BY FRED JAY SEAVER.

The following is a list of a number of species of Discomycetes (including Hysterineae) collected during the last year, which have not been reported in previous papers, also a few notes on other species. This paper is a continuation of the one published in the last volume of the Proceedings of the Iowa Academy of Science, and the number preceding each description is the herbarium number of the species described.

Sphaerosoma echinulatum Seaver was described in the Journal of Mycology from material collected near Iowa City in June, 1904. In June, 1905, the same species was collected in Germany, issued by Dr. Rehm in his Ascomycetes, No. 1601, and described in Annales Mycologici, 3: 409. A specimen of the German material has been examined by the author and as stated by Dr. Rehm in his description the German specimen corresponds almost exactly with the American except for a few slight differences in measurements of spores, asci, etc. The long spines on the outer surface of the spores which is characteristic of the species are common alike to the American and foreign specimens. That this species should occur in two such widely separated localities is interesting.

105. *Trichopeziza sulphurea* (Pers.) Fckl. Plants small, about 1 mm. in diameter, gregarious, sessile, hemispherical, clothed externally with a dense covering of delicate hairs which are filled with yellow coloring matter so that the whole plant when fresh has a sulphur-yellow color, color fading in dried specimens; hairs variable in length, as long as 75 mic., 8-spored; sporidia fusiform, nearly straight or curved, with several near their ends, blunt; hymenium concave, whitish; asci 65 to 75 by 6 mic., 8-spored; speridia fusiform, nearly straight or curved, with several guttulae, 16 to 20 by 2 mic.; paraphyses 2 to 4 mic. broad at their spices.

On dead stems of herbaceous plants. August, 1905. Mt. Pleasant, Iowa. Two collections were made both in the same locality.

106. *Mollisia atrata* (Pers.) Fckl. Plants gregarious, at first nearly rounded, becoming expanded, externally black, hymenium concave, cinerous, often quite dark; asci about 25 by 5 to 6 mic.; sporidia 5 to 6 by 2 mic.; paraphyses slender.

On dead herbaceous stems (*Ambrosia trifida*) August 3, 1905. Mt. Pleasant, Iowa.

The plants described here under this name are larger than is usually indicated for this species but other characters seem to conform closely.

107. *Ciboria sulphurella* (E. & E.) Plants gregarious, stipitate; stem variable in length, sometimes as much as an inch long and slender, but often very short; cup 2 to 5 mm. in diameter, a little concave; plants very

variable in color, often sulphur-yellow when fresh with a tinge of green; hymenium sometimes becoming reddish or reddish-brown, when dry almost black; sporidia elliptical, narrowed at the ends, 10 to 12 by 3 to 4 mic.; asci about 75 by 8 mic.

On petioles of ash and hickory. Autumn, 1905, Mt. Pleasant, Iowa.

This species has been found to be very common during the last season from summer to autumn in moist places on petioles of leaves which are partly buried. The length of the stem varies according to the depth at which the petioles are buried.

108. *Durella clavispora* (B. & Br.) The speicmens included in the herbarium of the author under this number are probably *Lecanidion atratum* (Hedw.). The latter species is very common and up to date has been collected by the author on fifteen different kinds of wood, bark, and herbaceous stems. The two species are closely related.

109. *Morchella crassipes* Pers. Plants large, pileus yellowish-brown, pits large and irregular; asci 8-spored; sporidia 20 to 23 by 10 to 12 mic.; stem large, often nearly as thick as the pileus and rather irregular.

In grassy place, Iowa City, Iowa. May, 1905.

110. *Phialea scutula* (Pers.) Gill. Plants small, 1 mm. in diameter or less, stipitate, stem about 1 mm. long, slender, plants yellowish, hymenium concave; sporidia 18 to 22 mic. long, clavate or nearly so, 2 to 3-guttulate and sometimes apparently 1-septate.

On *Polygonum* stems in wet places. Summer, 1905. Mt. Pleasant, Iowa.

111. *Propolis faginea* (Schrader) Karsten. Plants at first buried in the substratum finally breaking through, hymenium becoming exposed in elongated white patches, often several mm. in length and usually somewhat narrower, broken epidermis forming a rough margin; asci 8-spored, 100 by 12 mic.; sporidia elongated, rounded at the ends, straight or curved with 1 to 3 guttulae (usually 2) about 25 by 8 mic.; paraphyses slender.

On old wood of Sycamore (*Platanus occidentalis*), grape vine (*Vitis vulpina*), blue beech (*Carpinus caroliniana*) Mt. Pleasant, Iowa. January, 1906.

112. *Phaeopezia fuscocarpa* (Ell. & Hol.) Cups sessile, becoming nearly plane, externally yellowish-green, hymenium dark greenish becoming almost black, 5 mm. or less in diameter; sporidia 2-guttulate, greenish becoming brown, 7 to 8 by 3 to 4 mic.

On old wood. Mt. Pleasant, Iowa. Summer and autumn, 1905.

113. *Patellaria* (*Mycolecidea*) *triseptata* (Karst.). Plants sessile, about 1 mm. in diameter or less, round, at first concave becoming plane, black; asci about 50 by 12 to 14 mic., 8-spored; sporidia mostly in 2 rows, when mature brownish, 3-septate, a little constricted at the septa, 15 to 17 by 5 mic., often slightly curved; paraphyses slender, branched, forming a brownish epithecium.

On old wood. Mt. Pleasant, Iowa. Autumn, 1905.

114. *Sclerotinia seaveri* Rehm. Ann. Mycol. 4: 66. Cups 2 to 5 mm. in diameter, concave or nearly plane with a depression in the center, supported on a long stem, length of stem varying according to the depth at

which the substratum is buried under leaves and soil, plants dull yellowish-brown; asci 100 to 120 by 10 mic.; spores in 1 row, elliptical, about 12 by 5 mic.; paraphyses enlarged upwards.

On buried seeds of wild cherry (*Prunus serotina*) April, 1905. Iowa City, Iowa.

In the spring of 1905, Prof. B. Shimek brought into the laboratory at Iowa City, a number of discomycetes growing from the seeds of wild cherry. Prompted by this observation, the author afterwards made a large collection of this same species on cherry seeds which had become buried under leaves and soil in damp places. The species was observed and collected in several localities near Iowa City. During the following summer a specimen of this material was sent to Dr. Rehm, with other specimens, who described it as a new species under the name given above.

During this month (April 16, 1906) a specimen of *Sclerotinia* was collected by the author near Mt. Pleasant which corresponds very well with the material from which Dr. Rehm described this species in size, general appearance, spore measurements, etc. of the plants, but growing on the seeds of bass wood (*Tilia americana*). It may be that the two are the same species. The species is issued in Rehm's Ascomycetes, No. 1633.

115. *Helotium citrinulum seaveri* Rehm. Ann. Mycol 4: 67. Plants very small, about 1 mm. in diameter or less, externally whitish; hymenium lemon yellow, nearly plane; asci 35 to 45 by 5 to 6 mic.; sporidia straight or curved, fusiform, 7 to 8 by 2 mic.; paraphyses slender, about 1 mic. in diameter.

On dead stems of *Carex* sp. on hillsides, Iowa City, Iowa, May, 1905.

Two collections of this species were made at Iowa City in localities about two miles apart. The plants are small and not easily seen but were found in considerable numbers after some search on the dead stocks surrounding the living bunches of *Carex*.

Issued in Rehm's Ascomycetes, No. 1634.

116. *Gloniella ovata* (Cke.). Perithecia small, about 1 mm. in length or less, black, lips mostly tightly closed; sporidia inclined to fusiform but with ends rounded, one end smaller, 3-septate, constricted at the middle septum and slightly at the end septa 14 to 16 by 6 by 7 mic.

On old wood. July 25, 1905. Mt. Pleasant, Iowa.

This was thought to be a *Glonium* as many of the spores at first appear to be 1-septate, but on closer examination they are found to be 3-septate and hyaline.

117. *Glonium parvulum* (Ger.) Perithecia closely gregarious, small, not more than 1 mm. in length, black, lips closed; asci about 50 by 5 to 6 mic., sporidia hyaline, 1-septate, strongly constricted at the septum, about 7 to 8 by 4 mic.

On old wood oak and sycamore (*Platanus occidentalis*). Winter 1906. Mt. Pleasant, Iowa.

118. *Coryne urnalis* (Nyl.) Sacc. Cups rather large, nearly an inch in diameter, reddish-brown, hymenium at first concave, becoming nearly plane; sporidia fusiform, 24 to 25 mic. in length, with several delicate septa, often slightly curved.

On partly decayed wood. November 13, 1905. Mt. Pleasant, Iowa.

This species is closely related to *Coryne sarcoides* (Jacq.) but is distinguished by the larger size of the plants and spores. The two species seem to grade into each other.

119. *Barlaea miniata* Crouan. Plants small, 2 to 5 mm. in diameter, at first concave then nearly plane, orange-red; asci long, 150 by 16 to 18 mic.; sporidia globose, with 1 large guttula, epispore delicately reticulated, reticulations regular, 15 mic. in diameter; paraphyses slender, enlarged upwards, filled with orange granules.

On rather sandy soil, among moss. Iowa City, Iowa. May 22, 1905.

120. *Hysteropatella prostii* (Duby) Rehm. Plants small, 1 mm. in length or less, black lips spreading, asci about 50 by 10 mic.; sporidia slightly curved, brownish, 3-septate, about 15 by 4 mic.

On old bark (elm?). May 5, 1905. Iowa City, Iowa.

121. *Hysteropatella elliptica* (Fr.) Rehm. Plants scattered or collected in little groups, rather larger than the preceding, black, lips spreading sporidia straight or slightly curved, 3-septate, brownish, 23 by 8 mic.

On old bark (crab apple?)..August 1905. Mt. Pleasant, Iowa.

This and the preceding species are rather closely related. The two have been included with the pyrenomycetes but belong more properly with the discomycetes.

THE FOREST TREES OF EASTERN NEBRASKA.

BY CHARLES E. BESSEY.

In studying the distribution of the native forest-trees of Nebraska, I have evidence that most of them have migrated up the Missouri river and westward from it up the rivers which empty into it from the westerly side. A few species have come down from the Rocky Mountains and migrated eastward for greater or less distances.

It has long been my wish to arrange for a joint survey of the two sides of the Missouri river, having for its object the determination of the question of the rapidity of migration of plants on the two banks, and I present the following report in the hope that the Iowa botanists may be ready to join with those of Nebraska in making such a survey with reference to the tree flora.

Family PINACEAE.

Of our three native species only one occurs in eastern Nebraska.

Eastern Red Cedar (*Juniperus virginiana* L.) is found scattered over the eastern United States, and occurs in the various bodies of forests eastward of Nebraska. From these it has moved westward up the river valleys fully two-thirds of the distance across the state (2).

Family ANONACEAE.

Papaw (*Asimina triloba* (L.) Dunal). The large fleshy fruits which contain about eight large hard seeds are edible, and are picked up and carried off, or eaten directly by various quadrupeds. In either case it happens that some of the seeds are carried some distance from the parent trees. This species is very common in the Missouri forests, from which it has moved up the river valleys (4) in southeastern Nebraska (Richardson to Pawnee, Nemaha, Otoe, and Saunders counties).

Family SALICACEAE.

Black Willow (*Salix nigra* Marsh.) is common in the Missouri forests, from which it has spread up the streams, apparently across the state (5).

Almond Willow (*Salix amygdaloides* And.) is found abundantly in the Missouri forests, and has followed the river valleys across the Plains to the Rocky Mountains (6) and even to Oregon.

Shining Willow (*Salix lucida* Muehl.) occurs in the Missouri forests and has moved up the river to Cass county (7).

Sand-bar Willow (*Salix fluviatilis* Nutt.) is abundant in the Missouri forests, from which it has extended up the river valleys, across the plains to the Rock Mountains (8), California and Oregon.

Diamond Willow (*Salix missouriensis* Bebb) is common along the Missouri River in Western Missouri from which region it has extended its range northward along the river, and westward in the Republican, Platte and Niobrara river valleys to the western border (14).

Common Cottonwood (*Populus occidentalis* (Ryd.) Britton) is very abundant in the Missouri forests, from which it has passed up the rivers across the state (15) to the western border and beyond.

Family TILIACEAE.

Basswood or Linden (*Tilia americana* L.) The wing is an extension and enlargement of the bract of the peduncle of the inflorescence. The several spherical, dry fruits at maturity are attached nearly at right angles to this wing, which is slightly bent and twisted. At maturity the bract carrying the fruits separates at its base from the tree, and when caught by the wind whirls horizontally, carrying its freight of seed-bearing fruits often a distance of many metres from the parent tree. The linden occurs abundantly in the forests bordering the Missouri river southeast of Nebraska, and it now extends up that river along the eastern edge of the state (16) along the Niobrara river to Cherry county. It has extended up the valley of the Blue and Republican rivers on the south to Jefferson county, and the Platte river in the central portion of the state, to Nance county.

Family ULMACEAE.

The White Elm (*Ulmus americana* L.) is very abundant in the valley of the Missouri river southeast of Nebraska, and thence eastward to the Atlantic Ocean. From the southeastern forest body of this species it has extended up the several river valleys into all portions of the state (17) to the western counties.

Rock Elm (*Ulmus racemosa* Thomas) occurs commonly in the forest belt bordering the Missouri river southeastward, and from this region it has moved upward along the eastern border of the state (18) and up the Niobrara river near the northern boundary. While it has been recorded from but two stations (Cass and Keya Paha counties) it is highly probable that it occurs somewhat sparingly and perhaps intermittently along the eastern and northeastern border.

Red Elm (*Ulmus fulva* Michx.) is abundant in the Missouri river forest area, from which it has spread westward up the river valleys nearly or quite half way across the state (19). Beyond this area a single station is reported in Frontier County.

Hackberry (*Celtis occidentalis* L.). The globose one-seeded fruits are fleshy, and are in fact small drupes, much like thin-fleshed cherries. They are freely eaten by birds, and thus the seeds may be carried to considerable distances (even to many miles) from the parent trees. This species occurs abundantly in the Missouri forests, from which it has extended its range up the Missouri, Republican, Platte and Niobrara river valleys, across the plains (20) to the Rocky Mountains.

Family MORACEAE.

Red Mulberry (*Morus rubra* L.). The compound fleshy fruit (sorosis) consists of an aggregation of small one-seeded drupes, each surrounded by the flesny calyx-lobes. They are eaten by many birds, and the hard seeds are voided uninjured, and thus carried far away from the parent trees. The Mulberry is found abundantly in the Missouri forests, from which it has extended northwestward along the eastern border of the state to Cedar county (21).

Family OLEACEAE.

White Ash (*Fraxinus americana* L.) is common in the Missouri forest area, from which it has extended up along the eastern border of the state (22) to Sarpy county.

Green Ash (*Faxinus lanceolata* Bork.) is also common in the Missouri forest area, from which it has spread westward and northward along the river valleys, across the state (24) to the western counties.

Red Ash (*Faxinus pennsylvanica* Marsh.) is found with the preceding (23) and apparently has been disseminated with it.

Family POMACEAE.

Prairie Apple or Western Crab-Apple (*Malus iowensis* (Wood) Britt.). The fleshy fruit contains five two-seeded carpels, and is eaten by swine, cattle, sheep, horses and probably by deer, rabbits, woodchucks and a few other quadrupeds. Such fruits as are carried short distances and then dropped whole, or partially eaten, may supply seeds from which new trees may spring. This species is abundant in the Missouri forests, from which it has extended its range into Nebraska along the Missouri river and up the Niobrara river to Brown county (25). It has been distributed up the Nemaha river valley to Gage county, and the Platte river valley to Butler county.

Blackthorn (*Crataegus tomentosa* L.) occurs in the Missouri forests. from which it has moved up the river into the southeastern counties, from Richardson to Lancaster and Douglas (26).

Downy Haw (*Crataegus mollis* (T. & G.) Scheele) occurs in the Missouri forests, and has extended its range apparently with the preceding species to Lancaster and Douglas counties (27).

Juneberry (*Amelanchier canadensis* (L.). Med.). The little hard-seeded apples have a soft edible flesh which is greedily eaten by birds. Many of the seeds pass through the alimentary canal uninjured and are thus distributed over considerable distances. This species occurs in the Missouri forests, from which it has moved up the valley of the Missouri river as far as Sarpy county (30).

Family DRUPACEAE.

Choke Cherry (*Prunus virginiana* L.) is found in the Missouri forests, from which it has been carried northward along the Missouri river as far as Sarpy county, and westward in the Nemaha, Blue and Republican river valleys to Franklin county (31).

Wild Black Cherry (*Prunus serotina* Ehrh.) occurs in the forests of Missouri, from which it has spread into southern and eastern Nebraska, to Sarpy county along the Missouri river, and Franklin county in the valley of the Republican river (32).

Wild Plum (*Prunus americana* Marsh.) is common in the country east of the Plains, into and across which it appears to have been carried, so that it is now found in the Rocky Mountain region. It is found in all parts of Nebraska (33), even in the "pockets" in the Sandhills into which it must have been carried by birds.

Family CAESALPINIACEAE.

Kentucky Coffee Tree (*Gymnocladus dioica* (L.) Koch). The large monocarpellary fruits (15-18 centimetres long, 4-5 wide, and nearly 1 centimetres thick) contain about half a dozen large, spherical, very hard seeds, imbedded in a sweet pulp. The ripened pods hang on the trees for a part of the winter, and when they fall are picked up by quadrupeds which are attracted by their sweet odor. The hardness of the seeds prevents their being crushed. The tree occurs in the Missouri forests, and has followed the Missouri and Niobrara rivers northwestward to Rock county (34). In the southeastern part of the state it has followed the smaller streams westward fifty to sixty miles from the Missouri river.

Honey Locust (*Gleditsia triacanthos* L.) The large twisted and bent monocarpellary fruits (20-30 centimetres long, 2-2.5 wide, and 0.5 thick), contain ten or more very hard, flat seeds imbedded in a sweet pulp. The pods fall from the tree during the winter and are picked up and partly eaten by the larger quadrupeds as swine, cattle, etc., and doubtless were also by deer, buffaloes and other wild animals before the advent of white men. The hardness of the seeds preserves them from injury. The tree is common in the forests of Missouri and has been carried up the Missouri river and its tributaries so that now it occurs as far west as Franklin county in the Republican valley, and Holt county along the Niobrara river (35). It has also passed up the Nemaha and the Blue rivers to Gage and Lancaster counties.

Red Bud (*Cercis canadensis* L.). The bean-like pods are very flat and thin, and are well adapted to be carried in the wind a few metres. It is common in the Missouri forests and has extended northwestward into Nebraska (36) as far as Lancaster and Douglas counties.

Family PLATANACEAE.

Sycamore (*Platanus occidentalis* L.). The flowers grow in spherical heads, and produce compact, spherical clusters of oblong nutlets, which hang from long peduncles. When they fall from the tree (in the winter) they roll over the ground in the wind carrying their seeds with them. These trees are common in the forests of Missouri, from which they have moved up along the eastern edge of the state to Douglas county (37).

Family Rhamnaceae.

Buckthorn (*Rhamnus lanceolata* Pursh) is common in the Missouri forests, from which it has moved up along the eastern border of the state to Cherry county on the Niobrara river. It has followed the tributaries of the Missouri river (Nemaha and Blue rivers) to Gage, and (Platte river) Saunders counties (38).

Indian Cherry (*Rhamnus caroliniana* Walt.) occurs somewhat sparingly in the Missouri forests, from which it has advanced into eastern Nebraska (39) having been noticed at two stations (Cass and Saunders counties).

Family Elaeagnaceae.

Buffalo Berry (*Lepargyraea argentea* (Pursh) Greene) The small red or amber one-seeded drupes are edible, and are eaten by birds and thus carried away. The seed is protected from injury in the alimentary canal by its hard covering. This small tree is a native of the Rocky Mountain region and westward, from which it has been carried eastward across the state (40) to the banks of the Missouri river (Nemaha county).

Family Hippocastanaceae.

Buckeye (*Aesculus glabra* Willd.). The large brown shiny seeds drop to the ground as soon as mature, where they are quite conspicuous. Here they are picked up by large animals and sometimes swallowed. They are too hard to be easily masticated, and many must be rejected after trial. In the meantime they have usually been carried some distance from the parent tree. This species occurs in the Missouri forests, from which it has moved into Nebraska (41) as far as Richardson, Pawnee and Nemaha counties.

Family Aceraceae.

Silver Maple (*Acer saccharinum* L.) occurs abundantly in the Missouri forest area from which it has extended up the Missouri River nearly to the mouth of the Niobrara river (43) and westward fifty to sixty miles, in the moist lands along the streams.

Box Elder or Ash-leaved Maple (*Acer negundo* L.) grows abundantly in the Missouri forests, from which it has extended across the state (44). As this species occurs in the Rocky Mountains from New Mexico northward it is possible that some of the trees in western Nebraska have come down from the mountains and met those disseminated directly from the eastern forest areas.

Family Anacardiaceae.

Sumach (*Rhus copallina* L.). The small one-seeded drupes are crimson in color and have an acid flavor. They are eaten by birds, and their seeds are protected from injury by the bony seed coat. This species occurs in the Missouri forests, and has been carried northward (45) to the extreme southeastern corner of the state (Richardson county).

Family Juglandaceae.

Butternut (*Juglans cinerea* L.) is common in the Missouri forests, from which it has been carried into the southeastern part of Nebraska, as far as Gage, Johnson, Otoe and Cass counties (46).

Walnut (*Juglans nigra* L.) is found in abundance in the forests in the Missouri River Valley southeast of Nebraska, and from here it has moved up that river and up the Niobrara valley to Cherry county. It has occupied the southeastern corner of the state, and the Republican valley to Harlan county (47).

Shellbark Hickory (*Hicoria ovata* (Mill.) Britt.) is common in the Missouri forests, from which it has been carried into the southeastern counties of Nebraska, from Gage to Cass (48).

Big Hickory Nut (*Hicoria laciniosa* (Michx.) Sarg.) occurs in the Missouri forests, from which it has been carried northward along the Missouri river from Richardson to Sarpy counties (49).

Mocker-Nut (*Hicoria alba* (L.) Britt.) occurs in the Missouri forests, from which it is reported to have moved northward (50) into eastern Nebraska (*Sargent.*)

Pig-Nut (*Hicoria glabra* (Mill.) Britt.) is common in the Missouri forests, from which it has been carried along the Missouri River into eastern Nebraska from Richardson to Cass counties (51).

Bitter Hickory (*Hicoria minima* (Marsh.) Britt.) is common in the forests of the Misouri River Valley, from which it has been carried northward into the southeastern counties of Nebraska (52) from Richardson to Pawnee, Lancaster and Cass.

Family Fagaceae.

White Oak (*Quercus alba* L.) is common in the Missouri forests, from which it has been carried into southeastern Nebraska (53) as far north as Cass county.

Post Oak (*Quercus minor* (Marsh.) Sarg.) is found in the Missouri forests, from which it is reported to have moved northward (54) into southeastern Nebraska (*Sargent*).

Bur-Oak (*Quercus macrocarpa* Michx.) is abundant in the Missouri River valley forests, from which it has migrated along the river valleys fully half way across the state (55), reaching Harlan county on the south, Custer county in the center and Cherry county on the north. It occurs also, in the Black Hills of South Dakota, to which it was probably brought from the same Missouri forest area.

Yellow Oak (*Quercus acuminata* (Michx.) Sarg.) found in the Missouri forests, has barely reached Nebraska (56) in Richardson county.

Low Yellow Oak (*Quercus prinoides* Willd.) of the Missouri forests has barely reached southeastern Nebraska (57) in Richardson county.

Red Oak (*Quercus rubra* L.) is common in the Missouri forests, from which it has been carried northward along the Missouri river to Dixon county (58) and westward fifty or sixty miles.

Scarlet Oak (*Quercus coccinea* Muench.) occurs in the Missouri forests, and has entered the southeastern counties of Nebraska (59) from Richardson to Cass.

Black Oak (*Quercus velutina* Lam.) is found in the Missouri forests, from which it has moved northward along the eastern border of Nebraska (60) to the Platte river.

Black Jack Oak (*Quercus marilandica* Muench.) of the Missouri forests, has moved into the southeastern counties of Nebraska (61), Richardson to Pawnee and Nemaha.

Laurel Oak (*Quercus imbricaria* Michx.) is found in the Missouri forests, from which it has moved northwestward nearly or quite to the southeastern corner of Nebraska (62). Although this species has repeatedly been reported from this part of the state, I have seen no specimens which were collected within our borders. I have specimens collected in Missouri but a short distance from the southeastern extremity of Nebraska.

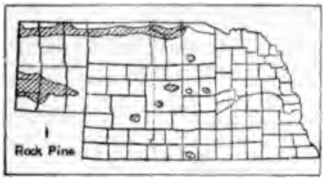
Family BETULACEAE.

Ironwood (*Ostrya virginica* (Miller) Willd.). The small nut is enclosed in a bladdery bag, which is so much larger that it serves the purpose of a wing. A dozen or more of these are aggregated into a loose strobilus. The obvious purpose of this structure is the easy transportation of the seed by the wind either in the whole strobilus, or the separate seed-bearing bags. The tree is abundant in the Missouri forests, from which it has extended up through the eastern and northern counties to Brown, Cherry and Sioux counties (63).

Walter Beech (*Carpinus caroliniana* Walter.). The small nut is attached to a foliaceous, somewhat three-lobed bract, which serves as a wing. These bracts are not crowded into a strobilus, but constitute a loose raceme. On falling from the tree the bracts serve to float the seed in the wind for some distance from the parent tree. This species occurs in the Missouri forests and has been reported from eastern (Sarpy county) and northern stations (Brown county) in Nebraska (64) to which it has apparently extended its range.

Canoe Birch (*Betula papyrifera* Marshall). This tree occurs in Minnesota and Montana, the Black Hills of North Dakota, and at a single station on the Iowa river in central Iowa (Hardin county). In Nebraska it is found only on the bluffs and in the ravines along the Niobrara River in Keya Paha, Brown, and Cherry counties (65). The occurrence of this tree in Nebraska is a puzzle to the botanical geographers for it is difficult to conceive of any means by which the seeds could be carried from the nearest known stations. Even should we consider the possibility of its dissemination from the Black Hills the difficulty is nearly as great, for the distance is fully one hundred and fifty miles, a part of it across the very rough country known as the "Bad Lands".

River Birch (*Betula nigra* L.) is found in the Missouri forests southeastward, and has extended its range northward along the eastern border of the state, being reported from Cass county (67).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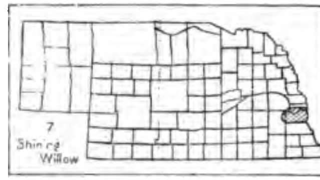
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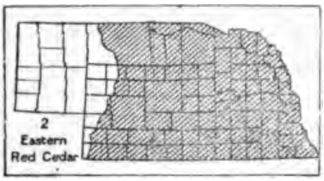
Shining
Willow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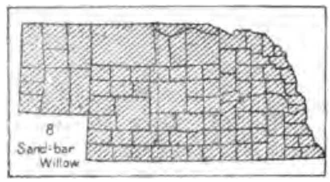
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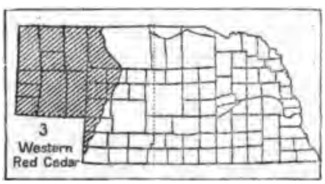
Sand-bar
Willow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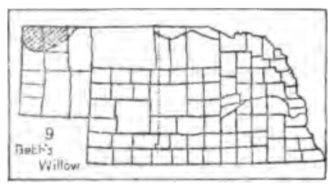
Western
Red Cedar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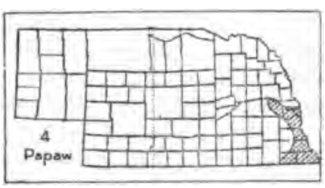
Bebb's
Willow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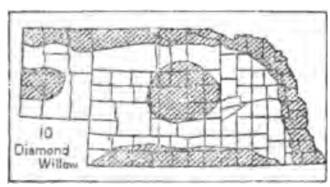
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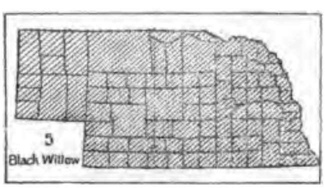
Diamond
Willow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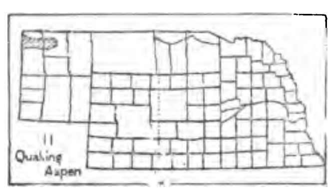
Black Willow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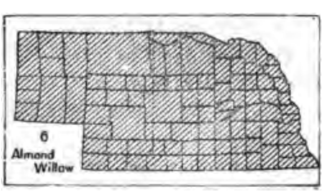
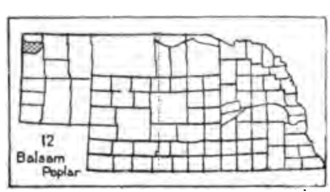
Quaking
Aspen


6
Almond
Willow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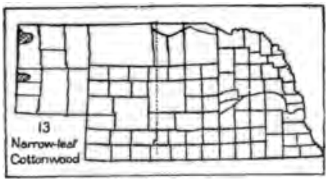
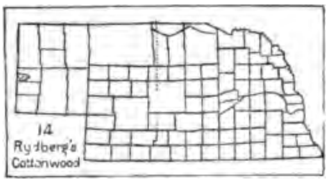
Poplar


13 Narrow-leaf Cottonwood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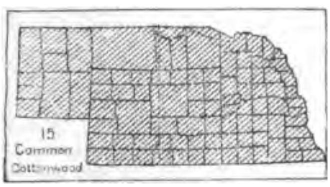
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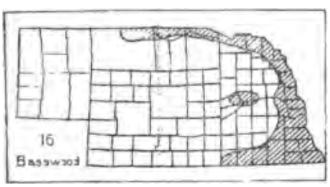
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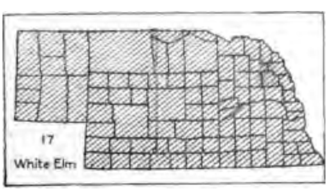
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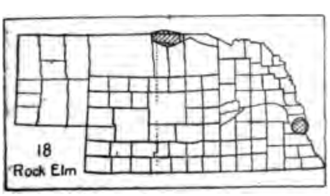
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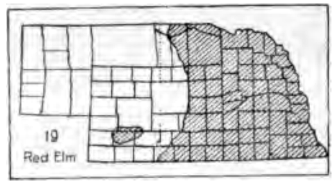
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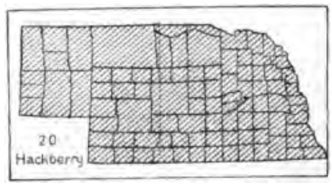
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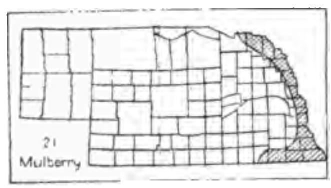
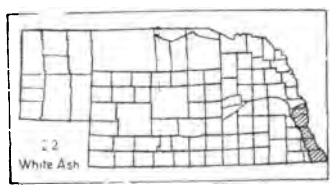
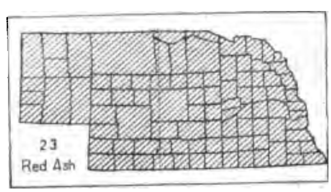

21 Mulberry


22 White Ash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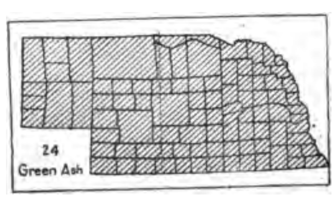
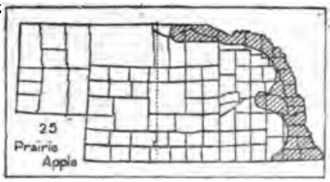
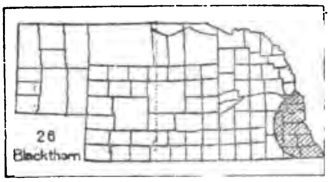

24 Green Ash


25
Prairie
Apple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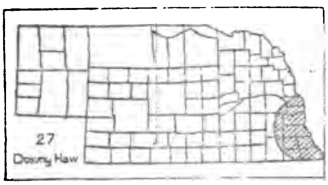
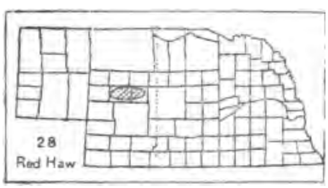
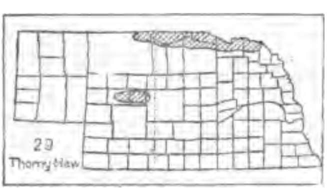

27
Downy Haw


28
Red Haw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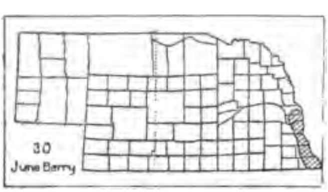
Thorny Haw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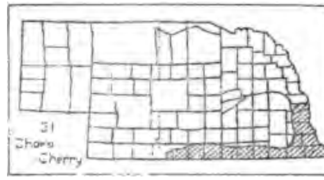
June Berry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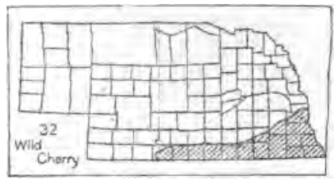
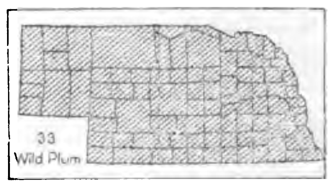
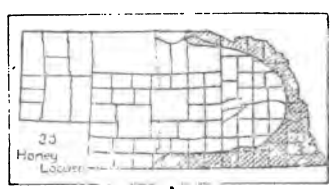
Cherry


32
Wild
Cherry


33
Wild Plum


34
Kentucky
Coffee Tree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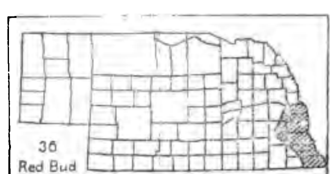
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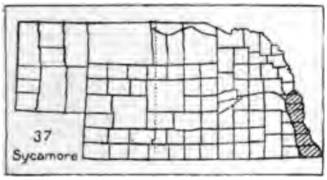
Red Bud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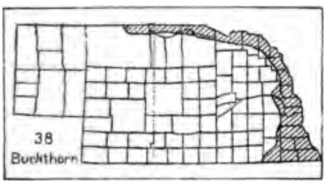
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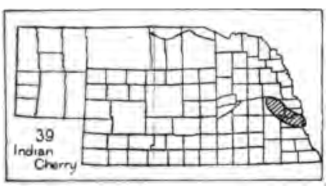
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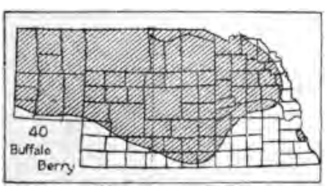
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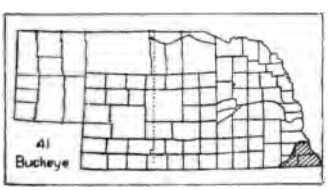
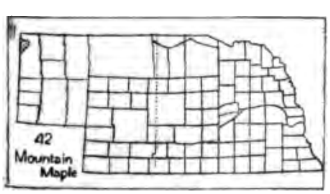
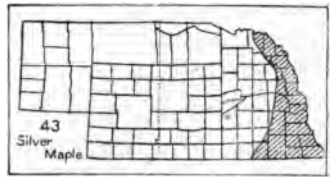
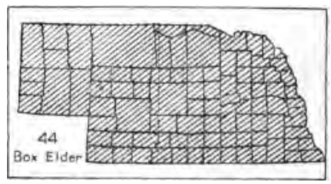
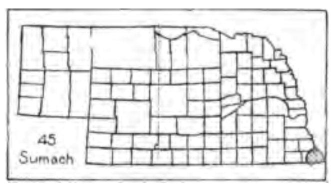

41 Buckeye


42 Mountain Maple


43 Silver Maple


44 Box Elder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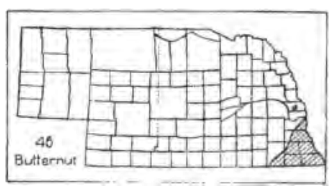
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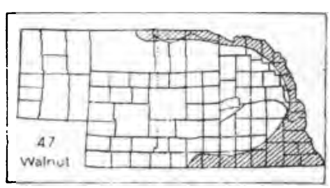
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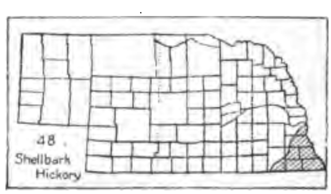
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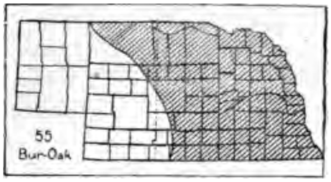
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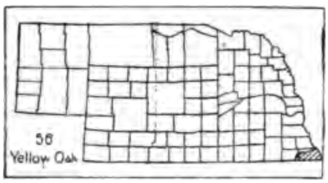
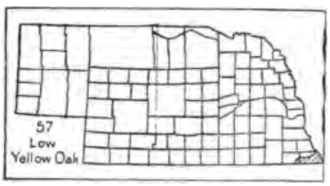
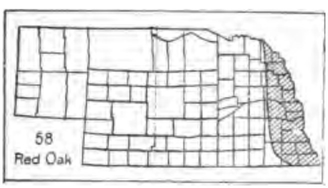
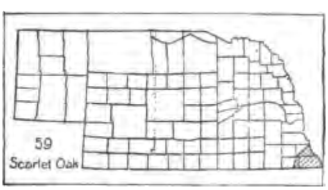
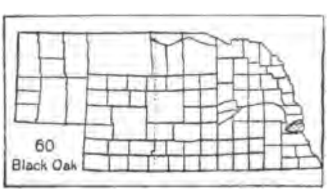
Bur-Oak

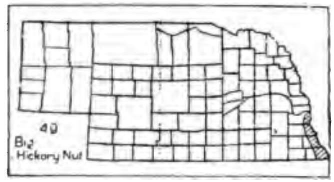

56
Yellow Oak

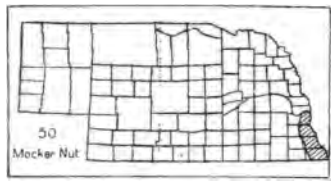

57
Low
Yellow Oak

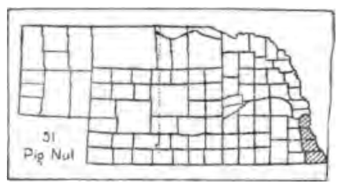

58
Red Oak

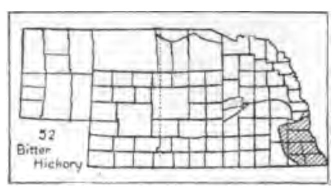

59
Scarlet Oak

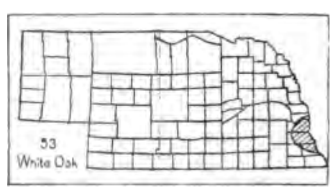

60
Black Oak

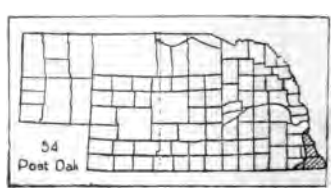

49
Big
Hickory Nut

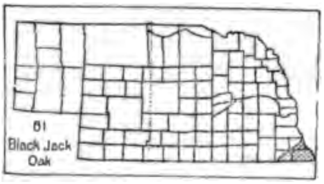

50
Mocker Nut


51
Pig Nut

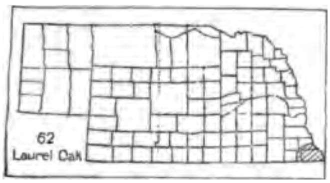

52
Bitter
Hickory


53
White Oak

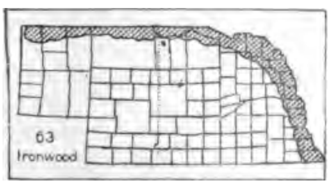

54
Post Oak



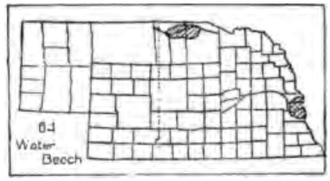
61 Black Jack Oak



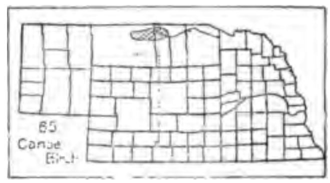
62 Laurel Oak



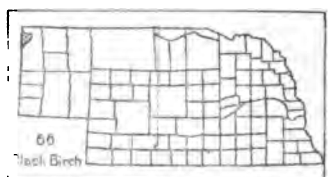
63 Ironwood



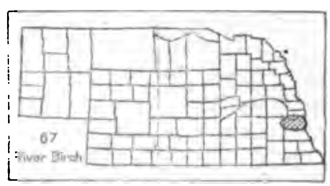
64 Water Beech



65 Canoe Birch



66 Black Birch



67 River Birch

SOME DISEASES OF ROCKY MOUNTAIN PLANTS.

BY L. H. PAMMEL.

Introduction.

Plates VII-XII.

Only a very small beginning has been made of the study of the parasitic fungi of the Rocky Mountain Region. A large number of interesting parasitic diseases affecting the cultivated plants, trees and shrubs, as well as herbaceous plants, occur in the Rocky Mountain region. The diseases that I have discussed constitute only a small part of those occurring here.

About a year ago the writer prepared a paper on the Cedar Apple Fungus and Apple Rust in Iowa, in which he referred to the more important apple rusts found in the Rocky Mountains. By permission of the chief of the Division of Vegetable Physiology and Pathology the writer used that portion of the paper containing Rocky Mountain species of Gymnosporangia and Roestelia prepared for that Division some years ago. In this connection I desire especially to express my thanks to Dr. Albert F. Woods and Mrs. Patterson of the Division for the many favors shown me in the preparation of this paper. I have therefore omitted from the present paper a discussion of the species of Gymnosporangia.

PERIDERMIUM, Lev.

Among the parasitic fungi of conifers none are more destructive than members of the genus *Peridermium*, first distinguished as a genus by Leveille[1] on characters given by Link[2]. The European species have been much more carefully studied with reference to their genetic connection than our own[3]. The only American writer who has studied our species with reference to their relationship is Farlow[4]. We are indebted to DeBary[5] for our knowledge of the biology and life history of *Chrysomyxa rhododendri* that produces its teleutospores on *Rhododendron* and the aecidium stage, *Peridermium abietinum* or *Aecidium abietinum*, on *P. excelsa*. The autoecious *Chrysomyxa abietis* is common in Europe on *Picea excelsa*. Other forms like *Peridermium (Aecidium) columnare* are connected with *Calyptospora goeppertiana* Kuhn. Von Tavel's account is simply a summary of work done by others[6].

1. Mem. Soc. Linn. d. Paris. 4: 212. 1826.
2. Willdenow in Linn. Sp. Pl. 6: 66. See also Fries Summa Veg. 2: 510.
3. Rees. Die Rostpilzformen der deutchen Coniferen. 86.
4. Notes on the Cryptogamic Flora of the White Mountains. Appalachia. 3: 322-251. Notes on some species of Gymnosporangium and Chrysomyxa of the United States. Proc. Amer. Acad. Arts and Sci. 20: 311-323. 1885. Abst. Jour. Myc. 1: 45.
5. ot. Zeit. 37: 760, 777, 801, 825, 841. *pl. 10.* 1870. See also DeBary Comparative Morphology and Biology of the Fungi Mycetozoa and acteria Engl. Trans. Garnsey & Bulfour. 283. Oxford. 1887.
6. Hartig. Lehrbuch der Baumkerankheiten. 56. Hartig. Textbook of the Diseases of Trees. Engl. Trans. Sommerville and Ward. 161.
   Tubeuf. Pflanzenkrankheiten. 383.
   Von Tavel. Vergleichende. Morphologie der Pilze. 123, 132.

Peridermium (*Aecidium*) *pini acicola* occurs on the needle of pines and produces its teleuto stage upon certain composites like *Senecio*. *Peridermium pini-corticola* occurs on the branches of pine.

Coleosporium senecionis (Pers.) Fr. being the perfect form of this fungus. An interesting Peridermium-like fungus has been described by Prof. B. T. Galloway[1] on *Pinus virginiana*. This fungus is connected with *Coleosporium pini*.

Cacoma pinitorquum and *C. laricis* have also been connected with a teleuto form. We are especially indebted to Hartig[2] for an account of the biology and life history of the former and Plowright[3] has determined the connection of the latter. Hartig has also obtained infection results with *C. laricis* on *Populus tremula*, *Melampsoro tremulae laricis*. It would seem therefore that two forms of *Caeoma* occur on *Larix*. *Caeoma* agrees with *Peridermium* except in the absence of the peridial layer.

The chief systematic works describing our species of *Peridermium* are those of Saccardo[4], Winter[5], Schroeter[6], Rees[7], Plowright[8], and Von Thumen[9].

There are several allied fungi like *Cacoma pinitorquum* and *C. laricis* which are connected with species of *Melampsora*. The former with *Melampsora tremula*, Tul. and the latter with *M. betulina*, (Pers.) Tul.

Economic accounts have been given by Hartig[10], Sorauer[11], Tubeuf[12], Ward[13], Willkomm[14], Frank[15] and DeBary[16].

The American species have been described by Farlow[17], Sargent[18], Peck[19], Von Thumen[20], Underwood and Earle[21].

The anatomy of *P. elatinum* has been treated by Dr. A. P. Anderson[22], and in a general way was described by DeBary[23]. However, the species are still in a very unsettled state. In Sargent's Silva are the

1. Bot. Gazette 22: 433. Jour. Myc. 7: 44.
2. Wichtige Krankheiten der Waldbaume. 83. pl. 5. f. 1-9.
Text book of the Diseases, etc. 166.
3. Einige Impversuche mit Rostpilzen. Zeitsch. f. Pflanzenk, 1: 130.
Text book of the Diseases, etc. 169.
4. Syll. Fung. 7: 835.
5. Die Pilze Deutsch. Oest. und d. Schw. 256, 257, 260, 261, etc.
6. Die. Pilze Schlesiens. 367-381.
7. Die Rostpilzformen d. Deutsch. Coniferen Halle. 1. c.
8. A Monograph of the British Uredineae and Ustilagineae.
9. Die Blasenrostpilze der Coniferen. Monographie der Gattung Peridermium Lev. Mitth. ans dem forstl. Versuchswesen Oest. 2: 297-323. Vienna. 1880.
10. Wichtige Krankh. d. Waldb. 1. c. Lehrbuch. 1. c. Textbook 1. c.
11 Handbuch der Pflanzenkrankheiten. 2: 244, 246, 250, 252.
12. Pflanzenk. 383, 386, 390. 393.
13. Timber and Some of its Diseases. 256.
14. Die Mikroskopischen der Feinde des Waldes. 1868.
15. Die Krankheiten der Pflanzen. 2: 185, 187, 189, 196, 206, 209.
16. Untersuchungen uber die Branpilze and die durch sie verusachten Krankheiten der Pflanzen und andere Nutzpflanzen mit Rucksicht auf das Getreide. 103. Berlin. 1853.
17. Appalachia 3: 239. Proc. Acad. Arts and Sci. 20: 320. Bull. Torrey Bot. Club 8: 85-87.
18. Silva of N. Am. 11: 12. 12: 26.
19. Rep. N. Y. State Museum of Nat. Hist. 25: 91. 27: 104. 28: 61, 86. Bull. Torrey Bot. Club. 6: 13.
20. 1. c.
21. Notes on Pine-inhabiting species of Peridermium. Bull. Torrey Bot. Club. 23: 400. See also Underwood and Earle Bull. Agrl. Exp. Sta. 80: 213; Underwood, Moulds, mildews and mushrooms, Earle in Mohr's Plant Life of Alabama Contr. U. S. Nat. Herb. 6: 192.
22. Ueber abnorme Bildung von Harzbehaltern und andere zugleich auftretende anatomische Veranderungen in Holze erkrankter Coniferen Inaug. Diss. Univ. Munchen. 1896.
Bot. Gazette 24: 309-344. Pl. 14-15. 1897.
23. Ueber den Krebs und die Hexenbesen der Weisstanne Bot. Zeit. 1867: 260.

following statements concerning: "The Spruce Rust, *Peridermium abietinum* Fries, of Europe, is very common, in the form called by Peck var. *decolorans*, on the dwarf Spruces which inhabit the subalpine summits of the mountains of the northeastern states, and its cluster-cups are so abundant toward the end of August in many places that those who walk through the dense dwarf Spruce forests are covered with their orange-colored spores. *Peridermium abietinum*, Fries, is considered in Europe to be connected with *Chrysomyxa rhododendri*, DC. but in northern Europe it has been supposed to be connected with *Chrysomyxa ledi*, Albertini & Schweinitz. In northern New Hampshire the *Peridermium* on Spruce, judging by its range and habit, is probably connected with *Chrysomyxa ledi*, Albertini & Schweinitz, on *Ledum latifolium*, as no *Chrysomyxa* has been found on *Rhodendron lapponicum* in that region."

Dr. Farlow[1] says, "In short it can be said of our *Peridermium balsameum* that it closely resembles in most respects the aecidial form of *Calyptospora goeppertiana* of Europe, and that not only in the White mountains but also in other parts of the country there seems to be a parallelism between the distribution of the *Peridermium* and the *Calyptospora*."

GEOGRAPHICAL DISTRIBUTION. The species of the genus are coetaneous with the distribution of the conifers, and the majority occur in the northern hemisphere. Of the unconnected species the following are credited to America. *P. piriforme, P. cerebrum, P. filamentosum, P. harknessi, P. raveneli, P. deformans, P. peckii, P. balsameum, P. ephedrae, P. conorum, P. elatinum.*

The following facts are stated in Sargent's Silva: "The determination of the Rusts which infest the conifers is difficult, owing to the fact that the greater part of them are aecidia or cluster-cups, which resemble one another closely, but, according to recent writers, are genetically connected with teleutosporic fungi of quite different species. The rusts of Pines, with few exceptions belong to the genus Peridermium which, like other aecidia, consist of orange or rust-colored spores arranged in chains contained within an envelope composed of colorless cells. The old species, *Peridermium pini*, Leveille, was supposed to have two forms, one producing cups on the leaves and the other cups or irregular disks on the trunks and branches. It has been shown that the forms on bark are connected with species of Cronartium, but the leaf Peridermium of European Pines is now separated into several species connected with different species of Coleosporium which grow on different Compositae, as Senecio, Tussilago, Inula, and on Euphrasia and other plants. Few experiments have been made with artificial cultures of the North American Peridermia, and the determination of our species must still be regarded as provisional. *Peridermium strobi*, common in Europe on *Pinus strobus* introduced from North America, is not known to occur in this country, nor has *Cronartium ribicolum*, Dietrich, with which it

1. Appalachia 3: 242.
2. Silva. 11: 12. 12: 26.

is associated, been introduced here. Of North American corticolous forms may be mentioned *Peridermium harknessi*, Moore, which forms nodes covered with confluent masses of aecidia on *Pinus ponderosa*, *Pinus radiata*, *P. sabiniana* and *P. contorta*, and *Peridermium cerebrum*, Peck, on *Pinus rigida*. Of North American acicolous forms may be mentioned *Peridermium harknessi*, Moore, which forms nodes covered with confluent masses of aecidia on*Pinus ponderosa*, *Pinus radiata*, *P. sabiniana*, and *P. contorta*, and *Peridermium cerebrum*, Peck, on *Pinus rigida*. Of North American acicolous forms of Peridermium the most common is perhaps identical with *Peridermium oblongisporum*, Fuckel. This is not uncommon on *Pinus rigida* in early summer, but the teleutosporic form with which it is said to be united in Europe, *Coleosporium senecionis*, Persoon, is certainly very rare here, although it has been noticed on *Senecio vulgaris* near Providence, Rhode Island. Besides the Rusts belonging to the genus Peridermium, *Coleosporium pini*, Galloway, attacks the leaves of *Pinus virginiana* in the middle states, causing bands of yellow discoloration and a premature shedding of the leaves. Unlike other rusts of pine trees, this species is a teleutosporic and not an aecidial form. The rusts which are often found in abundance on conee of various pine trees, especially in the southern and western states, need further study."

Three species of Peridermium are common in the Rocky mountain country at least the regions visited by the writer in the Big Horn mountains, Medicine Bow mountains and in the Uintah mountains. These species may be referred to *P. elatinum* on *Abies subalpina*, *P. coloradoense* on *Picea engelmannii* and *P. parryana*, *P. cerebrum* on *Pinus murrayana*. *Calytospjora goeppertiana* is also abundant and if the conclusions of the European investigators are correct we ought to find also *P. columnare*. The aecidia of the latter species are sufficiently distinct to attract attention, but they have not been observed . According to Dr. Farlow, *P. balsameum*, closely resembles *P. columnare* of European authors. Holway found *P. balsameum* on *Abies balsamea* near Vermillian Lake, Minn. in 1886, No. 208, specimens having been placed at my disposal by Prof. MacMillan. It may also be looked for on *A. subalpina* in the Rocky Mountains. *Peridermium engelmanni*[1] Thum. was described from Colorado specimens found on the cones of *Picea engelmanni*. The species has not been seen by the writer. It is said to be closely allied to *P. conorum* Thum.

PERIDERMIUM CEREBRUM, Peck.

HISTORY. This fungus was described by Peck[2] from specimens found near Center, New York on *Pinus rigida* collected by Dr. Lintner. In Saccardo's[3] Sylloge Fungorum it is reported from New York, New Jersey, Pennsylvania and District of Columbia. The species was first found in this country by Schweinitz[4] who described it as *P. pineneum*. Underwood

1. Die Blasenrost-pilze. 314.
2. Rep. N. Y. Sate Mus. of Nat. Hist. 25 : 91.
3. l. c. 7 : 837.
4. Jour. Myc. 7 : 44. Bot. Gazette 22 : 435.

and Earle, although they have not seen the type specimens of Peck's *P. pyriforme*, believe it should be referred to *P. cerebrum*. The malformations on *Pinus murrayana* in the west are similar[1]. In some cases there is but little swelling of the stem, but in others the enlargement of the stem or branch is very great.

The writer[2] found it abundant on *Pinus murrayana* in the Big Horn mountains of Wyoming in 1897 and in the Uintah mountains in 1900. Dr. Von Schrenk[3] reports it abundant on Bull and Lodge Pole pine.

General Characters. This fungus produces excrescences on the branches of young pines varying from half an inch to two inches in diameter. The disease may be confined to a small area or it may extend for five or six inches along the branch or young tree. Underwood and Earle state that in Alabama the galls may form a large ball, a foot or more in diameter. Enlargements of this kind on trunks of both *Pinus murrayana* and *P. scopulorum* have been observed in the Uintah mountains and in the Big Horn. These may have been caused by this fungus but a careful search failed to reveal its spores. On the small younger branches the aecidia break through the bark exposing the colorless thin lining of the cap of the peridium which is large, erumpent, and irregularly confluent. These characters are nicely shown as it occurs on *Pinus rigida*[4]. The bright colored spores are conspicuous when mature and are so numerous as to give the ground and grass surrounding the infected plant an orange color. The bark towards the edges is curved back forming a rim or border. The saucer-shaped aecidia with the irregular convolutions are very conspicuous. In older specimens the wood is uniformly brown and resinous. The longer the living tree stands the larger the excrescence becomes. In several instances these excrescences had been the result of twenty years growth. Hartig[5] mentions a case in which *P. pini-corticola* had infected a tree seventy years previously.

Microscopic Characters. The spores are orange colored but soon fade. They vary in form from spherical to ovate or pyriform, and are prominently roughened. The following measurements were obtained, length 3 to 187 mic., width 15—22 mic., the spherical ones having a diameter of 183 mic. The spores are borne in somewhat irregular chains coming from short thick basal basidia, under these basidia occur numerous short roundish cells that connect with the mycelium that vegetates between the cells of the bark but which occasionally may be found also in the cells. The peridial cells are colorless, long and narrow, somewhat pointed at the ends, imbricate and firmly attached together. 15 —20 x [illegible]—60 mic. The chlorophyll of the host is partially disintegrated. From the cortex the mycelium spreads to the wood by way of the cells of

1. Bull. Torrey Bot. Club. 23: 403.
2. H. H. Hume. Fungi Collected in Colorado, Wyoming and Nebraska. Proc. Iowa Acad. Sci. 7: 233 Contr. Bot. Dept. I. S. C. A. & M. A. 15
3. Forestry & Irrigation. 7: 60. f. 2.
4. Ellis. N. Am. Fung. 1022.
5. Textbook on the Diseases, Etc. 173. f. 103. Lehrbuch der Baumkrank. f. 16.

the medullary rays. The interior of the wood has a translucent appearance owing to the deposition of a large amount of resin. The fungus mycelium causes an extra cell proliferation especially well marked where the disease has been of long standing. In this case the diseased portion may be much larger than the stem below and above. The cell walls of the cortex except the strengthening elements do not give the lignin reaction but the walls of the tracheids respond readily to lignin, they have not therefore altered visibly. In many respects the pathological changes are similar to those described for *Peridermium pini-corticola* by Hartig.

"Wherever the mycelium obtains access, the starch-grains and other cell-contents disappear, their place being taken by drops of oil of turpentine, which form on the inside of the walls or saturate the wall substance itself. The cells are, of course, killed, death however being unaccompanied by browning of the tissues. The whole stem, to a depth of some three or four inches, is completely saturated with resin, a section of wood, as much as one or two inches in thickness, being more or less translucent."

"Each year the mycelium spreads from the diseased part into adjoining tissues, the rate of progress being usually somewhat more rapid longitudinally than horizontally. In proportion as the mycelium spreads so in the passage of the plastic materials confined to the sound side of the tree, in consequence of which the cambium in that region is stimulated to such a degree of activity as to produce exceptionally broad annual rings."

The following is Peck's original description of this fungus:

PERIDERMIUM CEREBRUM, Peck.

"Peridia large, convex, erumpent, irregularly confluent, forming brain-like convolutions, white, rupturing irregularly, the cells granulose radiate-striate on the margin; spores variable, ovate elliptical or subglobose, rough, yellow, .0008′ to .0011′ long.

Trunks and branches of young pines, *Pinus rigida*. Center. May.

This fungus forms excrescences from half an inch to two inches in diameter on the trunks and branches. On the smaller branches the excrescence puffs out equally on all sides of the branch. The outer bark comes off in large scales, revealing the bright yellow fungus which has produced the unseemly swelling.

This plant was first detected by Mr. J. A. Lintner, who brought me specimens and made known its locality."

MANNER OF INFECTION. This could not be determined for this species, nor has it been determined for the allied *P. pini corticola*. It may be through an abrasion of the cortical tissue induced by insects or mechanical injuries. A study of the material at hand indicates that infection takes place during the early stage of the development of the plant branch, during the first year of growth.

GENETIC CONNECTION. The spores mature during the latter part of July and presumably infect some other host plants. The European *Peridermium pini corticola* is connected with *Cronartium asclepiadeum*

(Willd.) Fr. according to some writers. Hartig[1] also mentions a connection with *Cronartium*, while Klebahn calls the *Peridermium* connected with the above *Cronartium*, *P. cornui* Rostr. & Kleb. As there are no Asclepiadaceous plants on which *cronartium* might occur in this region that host need not be considered.

Cronartium gentianum Thum.[2] is considered to be a synonym of *C. asclepiadeum* by Winter, this author stating that all hitherto described forms had better be reduced to two species. Saccardo, however, recognizes eight species, *C. asclepiadeum* Willd. having three varieties. The writer has observed in the Uintah mountains a species of *Cronartium* on *Gentiana* and *Comandra*, but the specimens were lost during the fire before a careful study and comparison with types could be made. the *Gentiana* occurring at higher altitudes and the *Comandra cronartium* at lower. Investigation may show that the corticolous *Peridermium cerebrum* is connected with this *Cronartium*. It may be of interest to mention now that a corticolous *Peridermium* has been found by the writer in St. Louis and that Burrill[3] reports *Cronartium asclepiadeum* Kze. var *thesii* Berk. from Illinois stating that it is identical with one distibuted by Ellis[4] from Newfield, New Jersey. Underwood and Cook[5] distributed this fungus from Syracuse, New York. Plowright's note[6] on *C. pini* is of interest in this connection.

"The connection between *Coleosporium senecionis* and *Peridermium pini* was first demonstrated by Wolff in 1872. He first found that the sowing of the aecidiospores of *Aec. pini*, both from the leaves and also from the young branches, on *Senecio viscosus*, *sylvaticus*, *vernalis*, *jacobaea*, and *vulgaris*, gave rise to the uredospores of the *Coleosporium*. In 1882, I repeated Wolff's culture on *S. vulgaris* with the aecidispores from the leaves with success. In 1883, the Rev. Dr. Keith sent me from Forres a specimen of *Aec. pini* on the branch of a young fir-branch, the spores from which I used for infecting two plants of *S. vulgaris*, but without success. Too much importance must not be attached to this failure, considering the distance from which the aecidiospores came. I have had, however, so many failures in infecting *S. vulgaris* with the aecidspores from *Aec. pini* var. *acicola*, that I think there must be more than one species included under this name. My friend, M. Max. Cornu informs me that in France he has succeeded in producing *Cronartium asclepiadeum* by sowing the aecidiospores of *Aec. pini* var. *acicola* on *Vincetoxicum officinale*. As neither the *Cronartium* nor its host occurs in Britain, we must conclude that the aecidiospores which M. Cornu employed belong to a distinct species."

1. Textbook of the Diseases of Trees. 172.
2. Oester. Bot. Zeitschr. 1878: 193.
3. Parasitic Fung. of Ill. 211.

Synonymy. *C. asclepiadeum* var. *thesii* Hook. Lond. Jour. Bot. 4: 311. *C. comandra* Peck. Bot. Gazette. 4: 128.

4. Exsic. Ellis. N. Am. Fung. 1082.
5. Cent. Illustr. Fung. 48.
6. Brit. Ured. & Ustilag. 249.

Nillson[1] states that in Sweden the *P. cornui* has a wider distributi than the host of *Cronartium*, the *Cynanchum vincetoxicum*, which pears to show that on the branches and stem of*Pinus sylvestris* there several species of *Peridermium*, thus he mentions the common occurrei of *Cronartium ribicola*[2]. Brunchorst[3] doubts the connection betw *Coleosporium senecionis* and *Peridermium pini*.

Underwood and Earle state that there must be some source of inf tion, "some considerable areas in eastern Alabama showing nearly ev tree of the species more or less affected".

Cronartium ribicolum Dietr. of Europe is connected with *P. str* Kleb., there is nothing like either of the species in the region un discussion. There are but two other species of *Cronartium* known, *flaccideum* (A. & Schw.) Wint. on paeonies and *C. balsaminae* Nie Neither of these need be considered. Several acicolous species of *P dermium*, one of which at one time was supposed to be related to *P. p* are connected with *Coleosporium*. *Coleosporium senecionis* and ot species may occur in the region but they were not found. The spec is certainly not connected with *Calyptospora goeppertiana* as this *P dermium* occurs at much lower altitudes than the *Calyptospora*.

GEOGRAPHICAL DISTRIBUTION AND HOST PLANTS. The species occ from the Atlantic to the Pacific and was first discovered in New Y by Lintner, on *Pinus rigida*. Ellis[4] distributed it from Newfield, N Jersey, on *Pinus inops* and Dr. Anderson found it on *Pinus echin* near Clemson College, South Carolina. Underwood and Earle[5] report from Massachusetts. (Underwood) on *Pinus rigida*, on *Pinus taeda* bama (Underwood and Earle) same species by Tracy from Mississi and Pinus sp. from Webster county, the same state (Stark) H. H. Hu from Florida where it is said to be abundant. Dr. Galloway reports as occurring near Washington[6]. The writer has found it on *Pi murrayana* in the Big Horn mountains and in the Uintah mounta in northeastern Utah. It is mentioned as occurring on the Lodge F pine and Bull Pine in Idaho by Dr. Von Schrenk[7]. It has probably b found on this pine at other points in the Rocky mountains. Seve other corticolous species are recorded from the west. *P. filamentosum Pinus ponderosa*, *P. harknessi* Moore on *Pinus ponderosa*, *P. insig P. sabiniana* and *P. contorta* in California. The *P. piriforme* Peck *Pinus* sp. in Georgia. The writer found what he took to be *P. pini ticola* on cultivated specimens of *Pinus sylvestris* in St. Louis and Ames some years ago. But specimens are not now at hand to sp authoritatively on this matter.

1. Nilson. Forstligt botaniska undersokningar i sydostra Nerike. 1892. (Forstl. bot. Untersuchungen in sudostlichen Nerike. 1892. arate Tidsk. f. skogshas hallning. 1893. Abst. Zeitsch. fur Pflanzenk 4: 187.
2. See Kiebahn. Kulturversuch mit heterocischen Uredineen. Zeitsch Pflanzenk. 2: 258. Hedwigia 29: 28-35. 1890.
   Ber. d. deutsch Bot. Gesellsch. 8: 63-66.
   Vorlaufige Bericht uber in Jahre 1894 angestellte Kulturversuche mit B pilze Zeitsch. f. Pflanzenk. 4: 194.
3. Nogle norske skovskydomme. (Eine Norwegische Waldrankheiten gen's Museum VIII. 1892. 3. Zeitsch. f. Pflanzenk. 4: 241.
4. N. Am. Fung. 1022.
5. 1. c. 403.
6. Jour. Myc. 7: 44.
7. H. H. Hume. Contr. Bot. Dept. I. S. C. A. & M. A. 15.
8. Forestry and Irrigation. 7: 60. f. 2.

ECONOMIC CONDITIONS. This fungus does serious injury to the young tree or branch. Not only is this true of the Uintah and Big Horn mountains but also as noted by Underwood and Earle, in Alabama where it does much damage to pines. The writer saw numerous small trees in the Uintah mountains that were very much dwarfed owing to the presence of this fungus. A part were nearly and some entirely killed by the parasite. The fungus mycelium penetrating the tracheids checks the flow of water and with the resin of the injured cortex check, transportation of the elaborated food products of the plant so that they do not reach the root, hence the root development is feeble. Owing to the unfavorable conditions existing in this region the growth of conifers is slow, hence it is important to properly maintain their root systems.

Peridermium elatium (Alb. & Schw.) Kunze and Schm.

HISTORY. Albertini and Schweinitz[1] first described the fungus which they found on Picea excelsa as *Aecidium elatium*. Link,[2] however, referred the fungus to *Caeoma elatium* but Kunze and Schmidt[3] placed the fungus in the genus *Peridermium*. Saccardo[4], Winter[5], and Schroeter[6] do not consider the species as definitely connected with a teleuto form and therefore they retain the Albertinian and Schweinitzian name of *Aecidium elatinum*.

DeBary[7] described the parasitic nature of this fungus in 1867. From an economic standpoint it has been treated by Rees[8], Hartig[9], Tubeuf[10], Ward[11] and Frank[12]. Special attention should be called to Heck's[13] monograph. Reference to the American occurrence of the fungus has been made by Farlow[14], Peck[15], Sargent[16] and Anderson[17].

GENERAL CHARACTERS. The parasite causes the so-called witches' broom or "hexenbesen" of the Germans. The distortions vary in size from a few inches to three feet in circumference and are from a few inches to three feet high. A single tuft or several may occur on a tree, being sometimes so numerous as to badly disfigure the same. One writer describes them as follows: "so that the distortion which can be seen from a considerable distance looks like small trees attached to the branches." The shoots are erect and rise from dense vertical tufts, the development of the lateral and latent buds giving rise to the formation of the bird's nest distortion. The large scars of the leaves of previous years are prominent. The leaves spread on all sides giving the bunch a peculiar appearance. These abnormal leaves are nearly horizontal. They are thicker

1. Conspectus Fungorum. 121. Pl. 5 f. 3. 1905.
2. Sp. Pl. 2: 66. 1825.
3. Die Schwamme. 141.
4. Sylloge Fungorum. 7: 825.
5. Die Pilze Deutschlands. Oesterreiches und der Schweiz. 261.
6. Die Pilze Schlesiens. 381.

For exsic. see Fuckel Fung. rhen. 290. Kunze Fungi Sel. 555. Rabenh Fung. Europ. 896. Herb. Myc. 388. Linhart Fung. Hung. 142.

7. Bot. Zeit. 25: 257-264. 1867. Aug. 16.
8. Uber den Krebs and die Hexenbesen der Weisstaune (*Abies pectinata* DC
9. Textbook of the Diseases of Trees. 179.
10. Pflanzenkrankheiten. 417.
11. Diseases in plants. 116.
12. Die Krankheiten d. Planzen. 2: 209.
13. Der Weissannenkrebs. Berlin. Julius Springer. 1894.
14. Appalachia 3: 240.
15. Rep. N. Y. St. Mus. of Nat. Hist. 27: 204. 28: 86.
16. Silva. 12: 101.
17. Bot. Gazette. 24: 309.

and shorter than the normal, yellowish in color, because of the absence of clorophyll and much swollen. Usually all of the terminal leaves are affected. In such cases the mycelium did not reach the shoot. The mycelium of the fungus stimulates the tissue of the cortex so that swellings of the bark and wood occur at the point of infection. The growth of the buds causes the formation of the so-called "witches' broom". The cortex of the "witches' brooms" is thicker and softer than normal. On the upper surface of the leaves of affected branches small yellowish spermagonia occur between the cuticle and the epidermal cell-wall The yellowish leaves bear two rows of cups or aecidia, 5-6 on each side on the lower surface of the leaf, they are sometimes hemispherical but more frequently elongated and elliptical. The lining of the cup is white, but the spores are bright orange color.

The fungus makes its appearance about the middle of July being fully mature by the first of August. It is perennial and hence recurs every year.

MICROSCOPICAL CHARACTERS. The small yellow spermagonia on the upper surface of the leaf vegetate between the cuticle and the remainder of the cell-wall and contain numerous small colorless spermatia. Their function is unknown. The leaf is permeated by colorless mycelium which sends haustoria into the cells.

The spores are borne in chains arising from short cells; they vary in shape from spherical to polygonal or elliptical; 13-18″ x 18 to 22″.

After the spores are discharged the leaves become dry and fall off, leaving a large somewhat depressed roundish scar.

ANATOMICAL CHANGES IN DISEASED TISSUE. A study of the anatomical characters of the diseased structures has been made by Hartmann[1] and Anderson[2]. Hartmann found that in affected branches the peridermium is thicker than normal while the hypodermal collenchyma is not thickened; resin canals are of unequal size, widely scattered and more abundant than in healthy tissues; cortical parenchyma more abundant; bast fibers not so numerous; xylem and phloem of the fibro-vascular bundle not so strongly developed in the diseased; on medullary ray cell more compact and the cell walls thickened. Anderson finds fewer stomata in diseased tissues, and that the hypodermal strengthening cells are often found in nests and groups, the diseased buds being covered over with a greater number of scales which are smaller than normal. Resin vesicles begin to form even in the first and second year of the diseased shoots, increasing in size until in five year old branches the blisters are from 3-8 mm. in diameter. In normal five year old branches they are never more than 1 mm. in diameter. The resin canals of diseased wood are usually found in the spring growth.

HOST PLANTS. Saccardo[3] records the following host plants: *Picea excelsa, Abies alba, A. balsamea, A. pectinata.* In Germany it has been observed on *Albies pectinata, A. nordmanniana, A. cephalonica, A.*

1. Anatomische Vergleichung der Hexenbesen der Weisstanne mit dem normalen sprossen derselben. Inaug. Diss. Univ. Frib. 1892. See Tubeuf. L. c. 420.

2. Comparative anatomy of the Normal and diseased organs of *Abies balsamea* affected with *Aecidium elatinum.* Bot. Gazette. 24: 309. *Pl. 14-15.*

3. Syll. Fung. 7: 825.

pinsapo; in Siberia on *A. pichta*, and in eastern North America on *A. balsamea*. It is common in the Rocky Mountain country on *A. subalpina*, and it has no doubt been found on other North American species.

INFECTION. Injuries in some cases are doubtless responsible for infection. Hartig says: "As I have always noticed small wounds on one or two year old witches' brooms close to their base—near the point, namely where they have developed from a bud—it may in the meantime be assumed, that infection occurs at such wounds. The mycelium of the fungus, which stimulates growth in a very marked manner, is perennial in the cortical and bast tissues of the stem, and even penetrates the cambium and the wood. Should infection occur at a part of a stem or branch where there are no buds capable of developing, the stimulated growth of the cambium induces the formation of a knob-like swelling of wood and to the more vigorous development of the cortex."

GENETIC CONNECTION. The experiments of European investigators have thus far not given very definite results. A fungus so often found. however, in the regions where it occurs would lead one to think that there must be some common teleutosporic stage. Wettstein[1] found that the spores of *P. elatinum* produced *Coleosporium campanulae* on several species of *Campanula*. In some cases, however, his experiments were unsuccessful, and a few non-infected trees produced the same fungus so that this writer has not definitely demonstrated its connection. In a table by Klebahn[2] on the connection of the different species of *Peridermium* the author expresses some doubt in regard to the connection of this species with *Coleosporium*. Other experiments made by the same author[3] seem to strengtnen him in his belief, nor does he consider it connected with *Pucciniastrum epilobii* Pers.[4]

In recent years *Melampsorella cerastii* (*M. caryophyllacearum* (DC.) Schroet.) has been considered the teleuto form of *Aecidium elatinum* and Fischer quite recently has confirmed their connection,[5] but it has not been worked out in this country. The species has been collected in Wyoming by Nelson[6].

This fungus differs from *Melampsora* in that the teleutospores are one celled and colorless and are produced in the cells of the epidermis. The uredo spores occur in pustutate scattered orange red masses and are enclosed in a semispherical pseudoperidium, they are ovate and elliptical 12-16″ x 22-26″ with a colorless membrane. The teleutospores occur upon last year's leaves, making their appearance in the spring, producing whitish or reddish flesh-colored spots which are frequently distributed over the entire surface of the leaf. The teleutospores are 13-15″ in diameter with a colorless and smooth wall. The sporidia are spherical,

1. Sitzungs b. d. K. K. Zool. bot. Gesellsch. Wein. 40: 44. See Klebahn Zeitsch. f. Pflanzenk. 2: 263.
2. Zeitsch. f. Pflanzenk. 2: 260-261. 1892.
3. Zeitsch. f. Pflanzenk. 4: 11. See also in this connection Wagner Zeitsch. f. Pflanzenk. 8: 257.
4. Zeitsch. f. Pflanzenk. 8: 200.
5. Fortsetzung der entwicklungsgeschichtlichen Untersuchungen uber Rostpilze 7-10. Ber. Schw. Bot. Gesellsch. 1902: Heft 12. Separate Abst. Bot. Centralbl. 89: 161.
6. Crypt. of Wy. 80.

7-9″, colorless. Magnus[1] has given an excellent account of the development of *Melampsorella*. He thinks the teleutospores develop immediately after the appearance of the uredo spores and that the ocurrence of the uredo spores in the spring simply indicates the further development of t..e fungus. The fungus is carried over from one season to the other by the mycelium which vegetates in the cortex and parenchyma of the stem. The teleutospores sometimes seem to divide longitudinally, but usually they develop crosswise, and as many as 2-4 cells may occur in a single epidermal cell. The germination of the teleutospores is interesting. In that process the promycelium is bent at right angles to the epidermal cell and divides into four cells, in the convex side there developes a small sterigma that produces from its apex a single sporidium.

GEOGRAPHICAL DISTRIBUTION. The wide distribution of this species in Europe has been known for some time. It is referred to by Plowright[2] as occurring in England on *Picea excelsa*, by LaSalle in Italy, and Tubeuf, Frank, Hartig, and DeBary and other writers mention its common occurrence.

It is found in Germany, Switzerland, Australia and Siberia. In North America it was first found by Sprague in New Hampshire in 1856 according to Dr. Farlow[3], and by T. P. James about the same time in the White Mountains. Dr. Farlow further states that Professor Macoun has collected it at Gaspe, Canada, and Prof. Brainerd at Ripton, Vermont. Anderson[4] reports it from Leech Lake, Minnesota; Prof. Peck from several localities in New York. It was common at the following points in the Uintah Mountains: East Provo Canon, Weber Canon, Bear river, Black's Fork, and Ashley creek, all occurring on *Abies subalpina* at an altitude varying between 8,500—10,000 feet, being in fact coexistent in its distribution with the Rocky Mountain balsam. Prof. Nelson[5] reports it on *Picea engelmani*, Battle Lake, Carbon Co., Wyoming. The host is most likely wrong. Miss Paddock and Ferd. Reppert report it common in the Big Horn Forest Reserve.

ECONOMIC CONSIDERATIONS. This is a most destructive parasite being much more abundant than any other species of the genus. The distortions it causes are often quite large. The fungus appears on both young and old trees and frequently on the terminal shoot which soon destroys the tree. Its mycelium is perennial and may therefore continue to produce spores for years, the broom in the meanwhile enlarging. As a result of the attack of this parasite, fissures arise in the bark which cause drying out and cracking and may lead to the attacks of other wood parasites. The only means of checking the growth of the fungus is to cut the tree below the affected branches. The wood of diseased trees is extremely brittle and where such is used the lumber is of very poor quality.

Peridermium abietinum (Alb. & Schw.)

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1. Ber. Deut. Bot. Gesell. 17: 337. Pl. 26.
2. British Ured. & Ust. 270.
2. Zeitsch. f. Pflanzenk. 1: 223.
3. Appalachia. 3: 243.
4. Bot. Gazette. 24: 310.
5. Crypt. of Wy. Rept. Agrl. Coll. & Wy. Agrl. Exp. Sta. 10: 30. No. 4244.

HISTORY. This fungus was described by Albertini and Schweinitz[1] as *Aecidium abietinum* from Listiania and placed in the genus *Peridermium* by Von Thumen, but most mycologists have referred the fungus to *Aecidium abietinum* Alb. & Schw. Dr. Farlow makes the following interesting account on the *P. abietinum* found in the White Mountains.

"Of the three forms mentioned, *P. abietinum* in confined to the higher mountains, being found in great abundance on *Abies nigra; P. balsameum* infests *Abies balsamea*, and extends from an altitude of about 4,000 feet to the level of the Androscoggin; and *P. peckii* which attacks *Abies canadensis*, is confined to the base of the mountains. Every one who has climbed to any of the higher mountains will recollect, with anything but pleasure, the entangled growth of dwarf *Abies nigra*, which forms a belt just below the region of bare rocks. It is in this dwarf growth the *P. abietinum* abounds on all the mountains I visited, namely Washington, Adams, Moriah and Success. I first found the aecidia in King's Ravine in the third week in August, when the peridia were just opening; but the fungus does not attain perfection until two or three weeks later, and it was so abundant on Moriah and Success in the third week in September that in attempting to penetrate the thicket, I was completely covered by the cinnibar-colored spores which were discharged in showers. Nearly every leaf on the smaller branches is attacked by the fungus and discolored. It is not to be supposed that the fungus attacks the larger trees of *Abies nigra* lower down on the mountains at an earlier date, and that what I saw was only the later development near the summit. The change is not gradual; but one comes suddenly upon immense quantities of the *Peridermium* as soon as the dwarf form of the *Abies* is reached. I am unable to distinguish this *Peridermium* from the *P. abietinum* (A. & S.) of Europe as seen in Fung. Eur., No. 1676, which is considered to be the aecidium of *Chrysomyxa rhododendri* (DC.). Of the original *Aec. abietinum* (A. & S.), two forms have been in later times recognized as stages of *Chrys. rhododendri* and *C. ledi*, respectively. The two forms are distinguished by slight differences in the peridial cells, difficult to recognize in dried specimens. As already remarked, our form resembles very closely No. 1676, Fung. Eur., which is cited by Winter as belonging to *Chrys. rhododendri*. Our form was called by Peck, *P. decolorans*, in the twenty-seventh report of the New York State Museum, and later it was called *P. abietinum* var. *decolorans* in Thuemen's[3] "Blasenrost-pilze der Coniefren." I examined with great care the *Rhododendron lapponicum* and *Ledum latifolium* near the dwarf spruce, but found no trace of *Chrysomyxa*. My search was so thorough that I think it safe to say that at that date there was no *Chrysomyxa* on any of the *Ericaceae* in the localities examined."

This fungus was distributed by Ellis and Everhart[4] as *P. abietinum* f. *engelmanni* and under the same name from northern Colorado collected by Prof. Crandall. Dietel[5] had made the Ellis and Everhart specimen

1. Conspect. Fung. 126. pl. 5. f. 5.
2. Appalachia 3: 240.
3. Die Blesenrost—pilze d. Coniferen Mitth. forstl. Versuchsw. Oestr. 314.
4. Fung. Columb. 876 2: N. Am. Fung. 2223.
5. Die Nat. Pflanzenf. 1: 78.

of the type of a new species, *P. coloradense.* The latter specimen contains only spermagonia but the Demetrio specimen shows the peculiar lacerate peridium due to the breaking off of the "cover" as it were, so nicely figured by Albertini and Schweinitz. And by Prof. Crandall[1] in his distribution of Colorado fungi as the accidium of *Chrysomyxa rhododendri.*

It appears to me that there are good grounds for considering it distinct from the European *P. abietinum* or the form found in the White Mountains of New Hampshire, a point which I shall discuss more in another connection. The species under the name of *decolorans* has been distributed by Holway on the*Picea mariana* from St. Louis Co., No. 93. Specimens kindly sent me by Prof. MacMillan agree with the White mountain specimens.

General Characters. This parasite produces bird's nest distortions as *P. elatinum.* The branches and leaves are much lighter in color than the normal being usually pale yellow. The distortions vary from a few inches to three or four feet in diameter. The fungus may appear on the trunks of trees as well as the upper and outer branches. It is perennial and produces where the fascicled branches appear a slight swelling of the stem, which is somewhat more pronounced when it occurs on the older branches. The diseased branches are terete and somewhat drawn out but not nearly so much swollen as in *P. elatinum.* The bark is pale straw colored becoming darker with age so that the affected branches close to the trunk are yellowish brown. The leaves in falling separate from their persistent bases upon which there are no fruiting bodies of the fungus. Small punctate brownish spermagonia occur in the grooves of the tetragonal leaves. The spermagonia of *P. abietinum* are described as yellowish. The elongated, orange colored, aecidia are few or scattered and occur singly, or in groups of single rows between the keels of the leaf. They are roundish, cylindrical or elongated and are from 1-16 to 1-8 of an inch in length. The aecidia in the true *P. abietinum* are much elongated and develop at right angles with the leaf; those of the species under consideration grow parallel with the leaf surface. The walls of the cup (peridium) are white and when ruptured, somewhat lacerated. The spores maturing in early August are orange colored. Leaves are never much swollen and except for their yellow appearance, appear almost normal.

Microscopic Characters. The cylindrical, lacerate, white, peridium consists of colorless, imbricated, closely connected cells measuring 26-375" x 262-1875 . The orange colored spores are large, spherical, subglobose or elliptical with roughened walls and thick epispore.

The wood is very light; the lumen of the tracheids is larger while the walls are thinner than in normal wood; resin canals are large with numerous secreting cells; the walls of the tracheids and medullary ray cells are not delignified; the pith cells except in the very youngest material, are empty, they are large thin walled and not lignified or but slightly so in old material; the mycelium is abundant in the cortex where it is

1. Colorado Fung. 2.

chiefly developed, ramifying between the cells and sending haustoria into the cells; from the cortex it extends into the woody portion by way of the medullary ray cells. The cortical parenchyma cells contain a few chlorophyll and starch grains. The starch is most abundantly found in the older portions of the "witches' broom". The septate mycelium is undoubtedly perennial in the buds, although Rees makes a contrary statement in regard to *P. abietinum.*

GENETIC CONNECTION. Elsewhere reference has been made to the results of infection experiments of DeBary, from which it was shown that *Peridermium abietinum* is connected with *Chrysomyxa rhododendri.* As noted in the paper by Farlow the *Chrysomyxa* was not found on *Rhododendron. Chrysomyxa ledi* on Ledum is probably connected with *P. abietinum* in the vicinity of the *P. abietinum* in the White Mountains.

In the Uintah Mountains and Medicine Bow Mountains where the writer has observed this *Peridermium* neither of these Ericaceous plants occurs. The only other Ericaceous plants in these regions are several species of *Pyrola* on which a *Uredo* has been found; *Kalmia glauca* usually free from fungi, and *Vaccinium* of which there are several species, the most common being *V. caespitosum.* The distribution of *Vaccinium* and *Kalmia* is coetaneous with the *Picea engelmanni.* The *Vaccinium* is commonly affected with *Calyptospora goeppertiana* whose aecidium is *Peridermium columnare* a fungus which has not been observed by us in the Rocky Mountains, though if abundant it should be easily recognized. It seems most probable that our *Peridermium* differs from the *P. abietinum* of Europe and of the eastern states, although resembling it in morphological characters.

In the Big Horn country *Ledum glandulosum* may be found and Prof. A. Nelson[1] reports *Chrysomyxa ledi* on it in the Yellowstone National Park, but this host is not abundant in the Uintah Mountains. Since writing the above *Chrysomyxa ledi* has been found in these mountains in close proximity to the *Peridermium coloradense.* If cultural experiments show that this form is distinct from the European *P. abietinum* the name of *P. coloradense* may be retained. Cultural experiments will no doubt show that it is distinct as it appears to be structurally.

EXOASCEAE

No commercial trees of the region under discussion are affected by the genera of the group Exoasci, although smaller ones like *Betula occidentalis, Prunus demissa. P. pennsylvanica* and *Quescus gunnisoni* are attacked by fungi of this group, which are at times quite destructive. Many of the species of the genus Exoascus produce curious malformations caused by the perennial mycelium of the parasite, living in the ends of twigs and stimulating the stems to put out tufts or small branches, which result in the formation of the so-called "witches' broom" or hexenbesen of the Germans.

1. The Cryptogams of Wyoming. Ann. Rep. Agrl. Exp. Sta. 10: 30, No. 6176

The Exoasceae have been made the subject of many excellent papers by European and American mycologists. We would call attention to those of Sadebeck[1], Johanson[2], Robinson[3], Rostrup[4], Atkinson[5], Patterson[6] and Farlow[7].

Because of the economic importance of the genus *Exoascus* to some of our cultivated fruits and ornamental plants many papers have been written on the subject; the following American writers having touched or discussed the diseases produced by it: Farlow[8], Erwin F. Smith[9], Galloway[10], Pammel[11], Stewart[12], Atkinson[13] and Pierce[14].

In addition to the papers of Sadebeck, Rostrup, and Johansen, who touch upon some of the species affecting forest trees, the following authors of text books pay some attention to the subject: Hartwig[15], Tubeuf[16], Comes[17], Frank[18], Sorauer[19], Zopf[20], DeBary[21], Brefeld[22], and Prillieux[23].

The following species are known to affect forest trees in this country: *Taphina aurea, T. caerulescens, T. virginiana, T. ulmi, Exoascus institae, E. varius, E. amentorum, E. aesculi, E. basteriospermus* and *E. nanus*. The following have been found by the writer in the Rocky Mountains *E.*

1. Untersuchungen uber die Pilzgattung, Exoascus, und die durch dieselbe um Hamburg hervorgerufenen Baumkrankheiten. Jahrbuch D. Hamburgischen Wissensch. Anstalten. 1883. 93-124. *pl.* 1-4. 1884.
Kritische Untersuchungen uber die durch Taphrina-Arten hervorgebrachten Baumkrankheiten. l. c. 1890 24. pl. 1-5. Jahrb d. Hamb. Wissensch. Anst. 8. Die parasitischen Exoasceen. Eine monographie 110. *pl. 1-3.* 1893. Jahrb. d. Hamb. Wissensch. Anst. 10.
2. Om svampslagtet Taphrina och dit horande svenska Arter. Ofversigt K. Vet. Akad Forhandl 1885: 29-48 pl. 1. Studier ofver svampslaget Taphrina. Bihang till K. Sv. Vet. Akad. Handl 13: 1-29 No. 4. *pl.* 1. 1887.
3. Notes on the genus Taphrina. Annals of Bot. 1: 163-176.
4. Taphrinaceae Daniae. Danmarks Taphrinaceer. Vidensk. Meddel. natur h. Foren. 1890: 246-264. Separate 21.
5. Notes on some Exoasceae of the United States. Bull Torrey Bot. Club. 21: 372-379.
Leaf curl and Plum pockets. Bull. Cornell. Univ. Agrl. Exp. Sta. 73: 319-355. 20 pl.
6. A study of North Am. Parasitic Exoasceae Bull. Lab. Nat. Hist. St. Univ. Ia. 3. 3: 89-135. *4 pl.* 1895.
7. List of Fungi found in the vicinity of Boston. Bull. Bussey Inst. 1: 438. 2: 227.
8. An Exoascus on cultivated cherry. Proc Soc. Prom. Agrl. Sci. 7: 25. 1886.
9. Field Notes. Jour. Myc. 6: 107-108. 7: 88-95. 7: 375.
10. Rep. U. S. Dept. Agrl. 1887: 366-369. *pl.* VJ.
11. Notes on some Fungi common during the season of 1892 at Ames, Iowa. Agr. Sci. 7. 20-27. Diseases of Plants at Ames 1894. Proc. Ia. Acad. of Sci. 2: 304.
12. Garden and Forest 8: 269.
13. Bull. Cornell Univ. Agrl. Exp. Sta. 73.
7. Newton B. Pierce in his valuable monograph upon Peach Leaf Curl, exhaustively discusses the morphology and biology of *Exoascus deformans* as well as the treatment recommended for controlling the disease. This work also contains a very full bibliography.
Peach Leaf Curl: Its nature and treatment. Bull. Div. Veg. Phys. & Path. U. S. Dept. Agrl. 20: 204. *30 pl.* 1900.
15. Lehrbuch der Baumkrankheitem. 115. Textbook on the Diseases of Treas. 131.
16. Pflanzenkrankheiten 167.
17. Crittogamia Agraria 161.
18. Die Krankheiten der Pflanzen. 2: 241. (2 Ed.)
19. Handbuch der Pflanzenk 2: 274.
20. Die Pilze. 437.
21. Comparative Morphology of the Fungi. Mycetozoa and Bacteria. 265.
22. Beitrage zur. Morphologie der Pilze. 1: 33.
23. Maladies des Plantes. Agricoles et des arbres fruitiers at forestiers causees par des parasites vegetaux. 392.

nanus, *E. Cerasi* and *E. institae*[1]. Sargent[2] in his Silva reports *Exoascus flavus*, now called *Magnusiella flava*, on species of *Betula populifolia*. No similar fungus was found on any of the other Rock mountain species of *Betula*.

EXOASCUS

The genus was first described by Fuckel[3]; Sadeback, who has made careful morphological and biological studies of these fungi, in his latest monograph retains the genus established by Fuckel. The perennial mycelium propagating the fungus from one season to the next, is copiously branched and sends ramifications between the cuticle and the remainder of the epidermal cells where the ascogenous layer, or hymenium, is developed. In the formation of the asci which may be densely crowded or somewhat scattered, the entire sub-cuticular mycelium is consumed; their development ruptures the cuticle and ensures the escape of the spores. The fungus causes deformation of leaves, fruit or stems.

Exoascus nanus Joh[4].

HISTORY. This fungus was described by Johanson[2] as occurring on *Betula nana*. There are several closely allied species, *E. betulinus* and *E. bacteriospermus* (Joh.) Sad., the latter having been collected at Lake of the Clouds, Mt. Washington by Myiabe and reported by Patterson. Tubeuf[5] states that the fungus causes hypertrophied branches of *Betula nana*.

GENERA CHARACTERS. .*This species* produces the so-called "witches brooms" of the western Birch (*Betula occidentalis*). From one to a dozen of these brooms may occur on a single tree. Hundreds of yellowish bunches may occur on a single branch. The statement that these bunches appear like foreign plants on the trees is very appropriate. Where this growth begins the branches are usually swollen. The newer growth of branches is also lighter in color but that is largely due to the yellowish, somewhat swollen leaves that have rolled edges. All of the leaves usually show the presence of the fungus, which when mature causes the lower surface of the leaf to appear covered with a white powder.

MICROSCOPIC CHARACTERS. The perennial mycelium occurs in the buds, from whence the infection spreads with the formation of leaves the following spring. I have not been able to study the development of the fungus, but in mature specimens the asci are not closely crowded, the cells are short, rounded at the apex, while the base of the ascus extends into the basal or stalk cell. The asci are quite uniform in size and measure 11-13″ x 18-3″. The stalk cell is short but wider than the ascus. The normal number of ascospores is eight, but there are frequently more. They vary in size from 3 to 7″. The elliptical are 4 x 5″.

1. H. H. Hume. Proc. Davenport Acad. 7: 255. Contr. Bot. Dept. 1. S. C. 15: 255.
2. C. S. Sargent Silva North America. 9. 49.
3. Eunm. Fung. Ann. Nat. Nass 15: 29 Symb. Myc. 252.
4. 1. C.: 108.
5. 1. c. 179.

ECONOMIC CONSIDERATIONS. This fungus was so abundant along Birch Creek that the vitality of the trees was seriously impaired, as a dozen or more of the "witches' brooms" might occur on a single tree. The writer has also observed its destructive work along the branches of Cache La Poudre river in the Medicine Bow Mountains.

Exoascus cerasi (Fuckel[1]) Sadebeck.

HISTORY. This species was described by Fuckel and has been referred to by American authors as *Exoascus wiesneri*[2]. It was described under the latter name by Rathay[3] and distributed by Ellis and Everhart[4] in North American Fungi.

This fungus has also been referred to as *Taphrina deformans* by Robinson[5] and as *Exoascus deformans* by Saccardo; Sadebeck[7], however, in 1893, referred it to Fuckel's *Ex. cerasi.*

GENERAL CHARACTERS. Infected leaves assume a dark color, become very much curled and somewhat puffed, twisted and wrinkled as in the peach leaf curl; and the branches of diseased trees are somewhat distorted, but in the western type, hexenbesen do not appear as in the European *E. cerasi* and as reported by Farlow[8].

MICROSCOPIC CHARACTERS. The mycelium is perennial in the buds and in the spring penetrates the tissues of the young leaves and develops on the lower surface in the shape of a subcuticular hymenium. The asci are extremely variable, but usually club shaped, rounded at the top and slender varying in size from 7-10″ x 30-50″. The stalk cells are from 5-8″ x 10-16″. There are eight ascospores which are aspherical or ellipsoidal, usually ellipsoidal. Mrs. Patterson[9] has the following interesting note on specimens examined during her study of the North American *Exoasceae.*

"I have examined it upon the leaves of *Prunus serotina* collected at Cambridge, Mass., by Dr. W. G. Farlow and Economic Fungi No. 128 from Alabama, and also upon deformed leaves of "cultivated cherry", (*Prunus avium?*) distributed as No. 2286 of Ellis, North American Fungi. I think to this species can be referred specimens of *Prunus americana* showing both branch and leaf distortion; some were collected in Illinois by Prof. L. H. Bailey, and several were sent me by Prof. L. H. Pammel, which had been found in various localities in Iowa. I am also indebted to Prof. Pammel for the opportunity of examining *Prunus hortulana* collected near Cedar Rapids, Iowa, by A. B. Dennis, and leaves of the Miner plum, a cultivated variety of *P. hortulana*, collected at Amana, Iowa, by A. Noe, both of which are doubtless affected by this species. It is also found upon several specimens of *Prunus pennsylvanica* from New Hampshire. I believe it proper to refer to this species the disease of *Prunus*

1. Symb. Myc. 252 as a var. of *E. deformans*. Fung. Rh. 2275.
2. Farlow. Proc. Soc. Prom. Agrl. Sci. 7: 25.
3. Oesterr. Bot. Zeit. 30: 225.
4. No. 2285 b. 2286. See also Krieger Fun Sax. 621. Von Thum. Myc. Univ. 2265.
5. Annals of Bot. 1: 168.
6. Syll. Fung. 8: 817.
7. l. c.
8. Proc. Am. Acad. 18: 84. Proc. Soc. Prom. Agrl. Sci. 7. 25: See, also Tubeuf Pflanzenk. 181.
9. Bull. Lab. Nat. Hist. 3. 3: 104.

virginiana leaves collected at Ute Pass, Col., and sent me by Prof. Wm. Trelease; in some respects it resembles *Exoascus deformans*, but the spores are larger, being 5 x 7″. *Prunus demissa*, the western choke-cherry collected in Nebraska by Mr. T. A. Williams, and sent me for examination by Mr. T. B. Galloway, shows the characteristic leaf and sprout formation and agrees microscopically with the fungus upon *P. virginiana*."

I have since examined a large amount of material that I have collected in the Rocky Mountains, and it seems to me that this fungus closely resembles the form described above and should be so referred and that Atkinson's[1] *E. varius* on *Prunus virginiana* should also be referred to this species.

I have found it only on *Prunus demissa* in the Rocky Mountains.

TAPHRINA, Fries.

History. The genus Taphina was established by Fries[2]. The careful and exhaustive studies of Sadebeck seem to warrant maintaining this genus distinct from *Exoascus*. The species of *Taphrina* are characterized as follows: They are all parasitic without perennial mycelium; the fungus is propagated entirely by the infection of spores. The spores germinate under favorable conditions, gain an entrance into the host and form a subcuticular mycelium not entering the tissues of its host. The hyphae are differentiated into two parts, one becoming the hymenium, the other taking nourishment from its host, with age loses its contents and finally disappears. These fungi affect the leaves by forming spots of various size, which sometimes may involve the whole lower or upper surface of the leaf.

The genus *Taphrina* is widely distributed in this country. A few of the species are troublesome to forest trees; *Taphrina aurea* occurring on the leaves of *Populus; T. johansonii* on the satkins of *Populus tremuloides* and other species; *T. virginica* on the leaves of *Ostrya virginica; T. ulmi* on elms and *T. caerulescens* on various species of oaks. The last is the only species observed by the writer in the Rocky mountain country, but others no doubt will be brought to light.

Taphrina caerulescens (Mont. & DesM.) Tul.

History. This fungus was described by Montague and DesMaziere[3] as *Ascomyces caerulescens* and was incorrectly named *Ascomyes quercus* by Cooke[4]. Robinson[5], however, correctly refers the South Carolina material to *T. caerulescens*. Dr. Robinson reports the fungus on a large number of hosts and these were added to by Mrs. Patterson[6].

1. Bull. Cornell Univ. 73:
2. Obs. Myc. 1: 217. 1815. Syst. Myc. 3: 520.
See also the following papers for accounts of the genus.
Tul. Ann. Sc. Nat. V. 5: 121. 125. 1866.
Johanson studier ofver Svampslagtet Taphrina. Bihang till k. Svenska Vet. Akad. Handlingar. 13: No. 4.
Sadebeck. Untersuch, uber die Pilzgattung Exoascus &c. Kritische Untersuchungen uber die durch Taphrina Arten &c. Die parasitischen Exoasceen Hamburg. 1893: 43.
Robinson. Notes on the genus Taphrina. Anals of Bot. 1: 163.
Patterson. A study of North American Parasitic Exoasceae. Bull. Lab. Nat. Hist. Ia. 3: 89.
Saccardo Syll. Fung. 8: 812.
3. Ann. d. Sci. Nat. 111. 10: 345.
4. Ravenel's Fung. Am. No. 72.
5. Notes on the geenus Taphrina. Annals of Bot. 1: 174: 6 North Am. Parasitic Exoasceae. 114.

GENERAL CHARACTERS. The fungus appears on the leaves in July at first causing somewhat round, yellowish spots which later become confluent and assume a greyish or bluish cast. Occasionally the greater part of the slightly swollen leaf may be involved. The fungus fruits on both sides of the leaves perhaps more frequently on the lower; but Dr. Robinson states that in *Quercus tinctoria* he observed asci only upon the upper and the same observation has been made by the writer in the examination of the Rocky Mountain Oak, *Quercus undulata*.

MICROSCOPIC CHARACTERS. The vegetative mycelium is sub-cuticular and gives rise to the asci. They are club-shaped, rounded at the top, without stalk-cells, but have one or more root-like processes which penetrate between the epidermal cells of the host; they vary in size from 18-23″ x 45-78″. Are very numerous and rod-like very variable, 1-3-4-7 1-4″. This fungus is without doubt common in the Rocky Mountains, but owing to the investigations of the writer being made rather late in the seasons of 1900 and 1901, good material was not then procured. He, however, collected it in 1895; on *Quercus undulata* var. *gunnisoni*, in the front range in the vicinity of Colorado Springs, where it is abundant.

ERYSIPHEAE, LEV.[1]

The mildews are widely distributed fungi producing troublesome diseases of the grape, many herbaceous plants, and not a few of our trees. The more important of the species affecting trees are the following: *Phyllactinia guttata* which occurs upon *Fagus*, *Carpinus*, *Corylus*, *Crataegus* *Castanea*, *Quercus* and many other shrubs and trees, and has been reported by Anderson[1] upon *Betula occidentalis* and *Typha latifolia*: *Podosphaera oxyacanthae* upon various species of *Prunus*, *Spiraea*, *Pyrus*, *Crataegus*, *Amelanchier* and *Diospyros*, the latter host being reported by Burrill[2].

Microsphaera alni upon many different hosts, especially *Carpinus caroliniana*, *Betula*, *Cornus*, *Viburnum*, *Syringa*, *Celastrus*, *Ulmus* and *Juglans*; *M. elevata* on *Catalpa speciosa* and *C. bignonioides*; *M. quercina* upon the various species of the *Quercus* or oak, as *Q. alba*, *Q. macrocarpa*, *Q. bicolor*, etc.; *M. calocladophora*, Atkinson upon *Quercus aquatica* and *Q. lauifolia*, *M. erineophila*, Peck; *Erysiphe liriodendri* upon *Liriodendron tulipifera*; *Sphaerotheca mali* upon the apple and *S. phytoptophila*, Kell. & Swi. upon the hackberry, (*Celtis occidentalis*); *S. lanestris*, on (*Q. agrifolia*).

The mycelium of these fungi vegetates on the surface of the plant, where it forms branching, septate, usually white and much interwoven, threads which abstract nourishment by means of little haustoria or suckers that are sent into the epidermal cells. The reproductive bodies are called conidia and are single, colorless, cylindrical, either oval or ovate, they are attached end to end in chains of somewhat elongated conidiophores. Perithecia arise from the mycelium and are the result of fertilization. They are usually globose, but occasionally are slightly flattened, at first colorless, finally brown, or in some cases when mature,

1. Ann. Sci. Nat. III. 15: 109-179. *pl. 6-11.* 1851.
2. Ellis & Everhart. N. Am. Pyrenomycetes. 21.

almost black. Appendages of various kinds develop from different portions of the perithecia. Asci arise from the base of the perithecia; they are thin-walled, colorless, oval, ovate, oblong or even nearly spherical, usually have a short pedicel and contain from two to eight hyaline oblong or oval spores. The spores escape by the rupture of the perithecia as they are not provided with an opening[1].

The powdery mildews are frequently affected by a parasitic fungus, *Cicinobolus cessatii*, which especially attacks the mycelium, conidia and conidiophores of the summer stage. The spores of this fungus also are contained in a brownish perithecium. Burrill and Earle call attention to the presence of the *Cicinobolus* spores in the perithecia of the host and they say as follows concerning this fact:

"Occasionally, on rupturing a perithecium, it will be found to contain minute bodies like *Cicinobolus* spores, instead of asci. This is considered a fourth kind of reproductive body by Berkeley (Introduction to Crypt. Bot. p. 78). It is more likely a case of the *Cicinobolus* developing its fruit within the growing perithecium."

I agree with these writers that these are simply the pycnidiospores of the *Cicinobolus*. It is a not uncommon occurrence on *Erysiphe cichoracearum.*

The *Erysipheae* have been worked over by quite a number of investigators and no attempt will now be made to review the literature on the subject. The most extensive monograph is that by Salmon[2]. Of the species most commonly found in the Rocky Mountains mention may be made of *Podosphaera oxycanthae, Phyllactinia suffulta, Microsphaera quercina* and *Uncinula salicis.*

Podosphaera oxyacanthae. (Dec.) D.By. The Powdery Mildew of the Plum and Cherry.

History. This fungus was described as *Erysiphe oxycanthae* by DeCandolle[3]. Wallroth[4] uses the name *Alphitomorpha tridactyla* W. Leveille[5], however, named it *Podosphaera oxycanthae* (D. C.) DB.[6]

The species is widely distributed not only in Europe but in eastern North America, and in some places is abundant in the Rocky Mountain country.

General Characters. This fungus develops its mycelium on both surfaces of the leaf, but usually on the upper where it produces a white, powdery, mealy substance, either in definite places or sometimes covering

1. The different genera are arranged as follows by Burril & Earle in the Parasitic Fungi of Illinois. Bull. Ill. Sta. Lab. Nat. Hist. 2: 392.

"*Sphaerotheca.*—Perithecelum containing a single ascus, appendages floccose, undivided.

Podosphaera.—Perithecium containing a single ascus, appendages dichotomously divided at the tip.

Uncinula.—Asci several, appendages coiled at the tip.

Phyllactinia.—Asci several, appendages straight, rigid, swollen at base.

Microsphaera.—Asci several, appendages floccose, undivided."

2. Monograph of he Erysiphaceae Mem. Torrey Bot. Club. 9.
Supplementary notes on Erysipheaceae Bull. Torrey Bot. Club 29: 183.

3. Fl. Fr. 6: 106. 1815 1: 10.

4. Compendium Fl. Germ. 4: 753. Ann. Wett. 4: 226.

5. Ann. Sci. Nat. III. 15: 135. *Pl. F. f. F. P. Lev P clandestina Lev*

6. Morph. II. An. Phys. d. Pilze. 3: 480.

the whole surface of the leaf. When it occurs in the latter way it seriously impairs the vital functions of the plant. The mycelium occurs mostly on the lower surface, and is inclined to be distributed in definite spots at least during the early stages of the disease, the young leaf freuently becoming brown on the upper surface.

MICROSCOPIC CHARACTERS. The mycelium is abundant and persistent, and spreading over the surface, sends small haustoria into the epidermal cells. The perithecia are usually large, from 65-100″; appendages from 8-20, much longer than the diameter of the perithecium, usually dark brown for about half their length, dichotomously forked, the forkings, however, not always evident; ascus elliptical or orbicular from 50-60″, thick walled and containing usually eight spores.

INJURY. This species was found to be especially troublesome to *Prunus demissa* sometimes injuring the leaves of large numbers of plants[1]. It is also found in nearly all orchards, occasionally upon the seedlings of *Prunus domestica*. The writer found it abundant in and about Colorado Springs[1]. It is also recorded by Nelson[2] as common in Wyoming and Anderson[3] in Montana.

Phyllactinia suffulta, (Reb.) Sacc.

HISTORICAL. This species was described by Rebent[4] as *Sclerotium suffultum*, but DeCandolle referred it to the genus *Erisyphe* using the specific name *coryli; suffulta* was restored to the species by Saccardo[5].

It is not necessary in this connection to expand greatly on this species because it is not common so far as the writer's observations extend, in the Rocky Mountains, although it is recorded by Anderson[6].

GENERAL CHARACTERS. The fungus occurs mostly on the lower surface of the leaf with a mycelium which is occasionally abundant and persistent or in some cases thin and evanescent.

MICROSCOPIC CHARACTERS. The perithecia are large, from 150 to 275″, with obscure reticulations; appendages few, usually large and rigid with a colorless base; asci from 4-20 or more, ovate and pedicellate; ascospores 2, occasionally 4.

UNCINULA, LEV.

This genus was established by Leveille[7]. It contains comparatively few species, but some of importance as producing destructive diseases especially of our forest trees. They are as follows: *U. clintonii*, Peck, upon the basswood, *Tilia americana; U. flexuosa*, Peck, on several species of *Aesculus; U. circinata* C. & P. upon various species of *Acer; U. aceris* (Dc.) Sacc., upon some California species of maple; *U. macrospora* Peck, upon several species of *Ulmus and Ostrya; U. parvula* C. & P., upon *Celtis occidentalis*, the latter occurring according to Seymour from the

1. See H. H. Hume. Proc. Davenport Acad. 7: 254. Contr. I. S. C. 15:
2. The Cryptogams of Wyoming. Rept. Agrl. Coll. Univ. Wyo. & Wyo. Agrl. Exp. Sta. 10: 20.
3. Jour. Myc. 5: 193.
4. Fl. Neom. 360. See also Leveille *Phyllactinia guttata* Ann. d. Sci. Nat. III. 15: 144. *Pl. 7. f. 11.*
5. Michelia. 2: 50.
6. Jour. Myc. 5: 193.
7. Ann. Sci. Nat. III. 15: 151. 1851.

Atlantic Coast to Washington; *U. polychaeta* upon *Celtis occidentalis* from Carolina to Mississippi and South America; *U. confusa* Massee. on the same host from Carolina; *U. geniculata* Gerard, on the red mulberry, *Morus rubra* in New York and Illinois; *U. necator* (Schw.) Burrill, the well known powdery mildew of the grape, and finally *U. salicis* upon various species of *Salix* and *Populus.*

Uncinula salicis (DC.) Wint.

HISTORY. DeCandolle[1] described this fungus under the name of *Erysiphe salicis*, and the form found on poplar was named by the same author as *E. populi*, while Wallroth[1] described it as *Alphitomorpha adunca* var. *populi*. Greville used the name *Erysiphe adunca*[3], and later Leveille[4] adopted the name *Uncinula adunca*, and by this name it had been generally known until Winter[5] referred it back to the old DeCandollean name.

There are very few economic references to the fungus. Frank[6], Sorauer[7] and Tubeuf[8] make brief references to it and Tubeuf has reproduced an excellent figure from Tulasne[9].

GENERAL CHARACTERS. The mycelium is white, prominent, amphigenous, though usually most abundant on the upper surface, starting from definite spots it soon spreads and sometimes covers the entire upper surface of the leaf. The perithecia are clustered or scattered, when mature black, and may be observed with the unaided eye.

MICROSCOPIC CHARACTERS. The mycelium is colorless, thin walled, sending lobed haustoria into the epidermal cells; erect conidiophores bear the somewhat elongated conidia in chains; perithecia large, from 100-160″ with small indistinct reticulations; appendages numerous hyaline, bent at the tip from once to twice as long as the perithecia; asci usually ovate from 5 to 12 or occasionally more, with a distinct pedicel, 52-60″ x 635-70″; spores 22-30 x 15-2″ number from 4-7. In the specimens examined on *Populus tremuloides* from the Rocky Mountains there were usually 6, 22-3″ x 1-151″.

DISTRIBUTION. This fungus is common not only in Europe, but throughout the United States. It is more frequently found upon *Salix* than *Populus*. In the Clear creek country, Colorado, however, it was especially abundant upon *Populus tremuloides* and the writer has frequently seen it upon *P. grandidentata* in Iowa. Burrill[10] reports it upon *Populus tremuloides, P. angulata, P. grandidentata, P. heterophylla, P. balsamifera* var. *candicans* and *P. monilifera*, and it, the latter host, is recorded

1. Fl. Fr. 2: 273. 1805 Winter Die Pilze Q: 40.
Fl. Fr. 6: 104. 1815. Enc. Bot. 8: 220.
2. Verh. Naturf. Freunde. 1: 37, 42, Fl. Crypt. Germ. 4: 755.
3. Scott. Crypt. Fl. 5: *Pl.* BTF. Note the name as given by Greville in this reference is *Erysiphe adunca*.
4. Ann. Sci. Nat. III. 15: 151. *Pl.* G. *f.* VE.
5. Die Pilze. 2: 40.
6. Die Frankh. d. Pflanzen, 2: 261. (2 Ed.)
7. Handb. d. Pflanzenk. 321, 331.
8. Pflanzenk. 196.
9. Selecta Fungorum Carpologia. 198. *pl.* B.
10. l. c.

by Mr. Freeman[1], but he does not report the fungus on *P. grandidentata*, or *P. tremuloides*. It is especially common on the species of willow of which *Salix richardsoni* is the type.

Black Knot of Plum. In concluding the portion of this paper bearing upon the subject of fungus diseases mention should be made of *Plowrightia morbosa* upon *Prunus demissa* and *P. americana*. The writer observed a few of the wild specimens of *Prunus americana* affected by fungus in the vicinity of Greeley, and it is common on *Prunus demissa* in the Uintah Mountains, in some places, and doubtless in other sections of the Rocky Mountains. It has not been observed in the region under consideration, on the cultivated *Prunus americana*.

Root Rot. Mention may also be made here of a root rot that affects shade and forest trees, as *Acer saccharinum*, (*A. dasycarpum*) and *Fraxinus viridis*. The disease is quite common both in the Salt Lake country and in the eastern Rocky Mountain region where it is not uncommon to find forest and shade and fruit trees assuming a yellow tint. By many persons this is supposed to be caused by an excess of alkali in the soil and no doubt such is frequently the case but the writer's attention was called by Professor Paddock to the yellowing of fruit, shade and forest trees in the vicinity of Fort Collins, which were undoubtedly affected by a root rot fungus. In one instance, *Dematophora necatrix* was found in connection with the roots, but there was not time for a thorough investigation and Professor Paddock was already carrying on work upon similar trees[2].

Disease Due to Flowering Plants. Throughout the entire Uintah Mountains several parasites of the genus *Arceuthobium* are quite troublesome to conifers. One species *A. americanum* is common on *Pinus murrayana*, another species, *A. robustum*, also occurs in the Rocky Mountains and was abundant in the foothills of the front range west of Fort Collins, and *A. douglasii* is found in Clear creek canon. The genus *Arceuthobium* belong to the order *Loranthaceae* or mistletoe family, represented in the southern states by *Phoradendron flavescens*, called the American mistletoe which is abundant on various species of deciduous trees like the oak and elm. This mistletoe is very extensively used for Christmas decoration. Several other species of *Phoradendron* are native to the west, one only occuring in the Rocky Mountain region, namely, *P. juniperinum*, The only eastern representative of *Arceuthobium* is *A. pusillum* which produces dwarf or clustered stems on the black spruce, *Picea nigra* in eastern North America, especially in the Adirondacks, in New York, New Hampshire and Maine. It has been made the subject of several notes by Peck[3] who gives a description of the parasite on the black spruce *Picea nigra* and by Von Schrenk[4] who calls attention to the "witches' brooms" produced by it on *Picea mariana* and the injury done especially in causing premature death.

1. Minn. Bot. Studies. 4: 428. *P. deltoides* acc. to Kew *Monilifera grandidentata*. *Populus angulata*—*P. monilifera*, and both—*P. deltoides* according to Britton and Brown.
2. Professor Paddock has recently discussed this trouble in a short paper. Bull. Col. Agrl. Exp. Sta. 69: 4.
3. Rept. New York State Museum of Natural History 25: 69. 27: 112. 28: 83.
4. Rhodora 2: 2-5 *pl.* VB. Zeitsch f. Pflanzenk 11: 137.

The *Loranthaceae* have not been revised by any recent botanist but Dr. Engelmann[1] has in various papers, described the different species.

Dr. D. T. MacDougal[2] has contributed a note on the seed dissemination and distribution of *Razoumofskya robusta*[3].

The *Loranthaceae* are evergreens which are parasitic upon shrubs or trees, they are of a greenish or yellowish green color, are dichotomously branched and have stems with swollen joints. The flowers are small and inconspicuous, greenish, dioecious; the 2-5 sepals are coherent at the base; anthers as many as the sepals and inserted upon them; ovary inferior, one celled; fruit, a berry with a gelatinous endocarp.

The genus *Arceuthobium*, parasitic on Conifers, has rectangular branches and small connate scale-like leaves; flowers terminal or axillary, single or several from the same axil, which often form spikes, opening in the summer and maturing fruit the second season. The seeds of *Arceuthobium*, as those of *Phoradendron* and the European *Viscum*, are scattered by birds. In regard to the dissemination of the seeds of *Arceuthobium*, Dr. MacDougal states that the single seeded berries are borne on short stalks which are curved semi-circularly and from which they are easily detached wnen ripe. The berry is joined to the stalk by a scission layer, which is ruptured by the slightest touch or may be pressed away by the action of forces set up in the berry which also expel the seed. The expelling of the seed in this way has been known for many years and has found its way into literature. The writer was unable to find ripe material to study the method of its dissemination. The fact that where one tree is affected surrounding trees are usually all, both young and old, diseased shows plainly that birds must be an unimportant factor in the dissemination of the seed. One may find whole groups or patches of affected trees where the *Arceuthobium* had started at a central point and gradually infected all. *A. americanum* produces all or nearly all of its staminate flowers in terminal distinct peduncle-like joints which are more or less paniculate. Staminate plants are dichotomously or verticillately branched and are much longer than the fertile ones. This is the most destructive species in the Uintah Mountains, sometimes covering an area of several acres in extent, where in some cases, nearly every tree is affected. It is especially noteworthy that where the trees occur isolated as after a fire, scattered trees are affected with this parasite. It usually attacks the lower branches, but may extend upward producing large fascicled branches which have received the common name of "squirrels' nests" or "witches' brooms". In isolated areas on Black's Fork we found as many as fifty per cent. of the trees were affected, and in some cases more than five per cent. had been killed by the parasite.

A. robustum develops axillary spikes either simple or compound of staminate flowers which have short and broad lobes. It is common upon

1. Gray's Plant. Fendl. Mem. Am. Ac. N 5: 4: 1849. Gray. Plant. Lindh. 2: Boston Jour. Nat. Hist. 6: 1850. Trans. Acad. Sci. St. Louis. 3: See Bot. Works of the late George Engelmann collected for Henry Shaw, Esq.. Edited by Trelease & Gray. Wheeler's Rept. U. S. Geographical Surv. W. of the 100th meridian Botany J. T. Rothrock 6: 251. Botany California 2: 106.
2. Minn. Bot. Studies. 2: 169 *pl. 15, 16 f. l.*
3. This is referred to by Engelmann as *Arccnthobium robustum.*

Pinus [illegible] in the foothills of the front range west of Fort Collins in one case, many per cent. of the trees were affected and many had been killed. Like *Arceuthobium americanum* it produces large fascicled branches, as many as a half dozen may occur upon a single tree and ultimately destroy it.

The last species here considered. *A. douglasii* Engelm. was found once in the Uintah Mountains on the south side of the range; the writer has also observed it in Clear Creek canon on *Pseudotsuga douglasii.*

It produces small slender branches, one-fourth to one inch high, nearly erect, with flowers in short usually 5-flowered spikes; staminate flowers small or narrow with orbicular acutish lobes fruit two and one-half lines long. Dr. Engelmann[1] in speaking of the character of this species says, "Similar to the last, but smaller and never with verticillate branchlets or flowers, which are so common in that species. The thallus-like tissue or stroma, which creeps along within the bark of the host plant, buds out in autumn all along the three years old shoot; after about twelve months, the flower-buds are formed, to open in the following spring, after which the life of the male plant is exhausted; but it takes another year to perfect the fruit. The female parasite, now fully three years old, generally dies, but sometimes leaves and fructifies another season. The Northeastern *A. pusillum*, Peck, behaves in the same manner, while in *A. americanum* and some other species the buds of the parasite make their appearance at first only among the older bud-scales of the pine branch."

ECONOMIC CONSIDERATIONS. The presence of these parasites upon their respective hosts is injurious to the timber, causing the same to become brown and brittle and wholly unfit for lumbering purposes. The growths may be held in check by cutting off diseased young branches, as they are the first attacked and may be considered centers of infection. The writer has seldom seen these parasites destructive in dense timber.

Dr. Hermann Von Schrenk has long been interested in these parasites. It is to be hoped that a thorough study may be made of their specific characters as well as of their injurious effects since they include some of the most destructive of all of the parasitic diseases of the different conifers of the Rocky Mountain region.

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1. The species was described by Engelmann in Wheeler U. S. Geographical Survey west of the 100th meridian 6: 253.

THE LILIALES OF IOWA.

By T. J. Fitzpatrick.

The order LILIALES consists of monocotyledonous plants, having for the most part regular and complete flowers, the perianth being well developed and made up of three or six parts. Ovary compound, superior or inferior.

This order is represented in Iowa by eight families, twenty-three genera, and about fifty-two species.

Ovary superior, very rarely inferior.
  Perianth-segments distinct, green or brown; herbs with a grass-like aspect. Fam. 1. *Juncaceae*.
  Perianth-segments distinct, or partly united, at least the inner petal-like.
    Fruit a capsule.
      Capsule usually septicidal; plants rarely bulbous. Fam. 2. *Melanthaceae*.
      Capsule loculicidal; plants mostly bulbous. Fam. 3. *Liliaceae*.
    Fruit a fleshy berry.
      Erect herbs; tendrils none; flowers perfect. Fam. 4. *Convallariaceae*.
      Vines, climbing by tendrils, or rarely erect; flowers dioecious, in axillary umbels. Fam. 5. *Smilaceae*.
Ovary inferior, wholly or in part.
  Stamens 6 in our species.
    Erect perennial herbs; flowers perfect. Fam. 6. *Amaryllidaceae*.
    Twining vines; flowers dioecious. Fam. 7. *Dioscoriaceae*.
  Stamens 3, opposite the outer corolla-segments. Fam. 8. *Iridaceae*.

1. JUNCACEAE Vent. Tabl. 2: 150. 1799.

Rush Family.

Annual or perennial grass-like herbs, commonly tufted and growing in moist places, with small regular 6-parted glumaceous flowers appearing singly or in clusters, spikes, or heads and disposed in panicles, corymbs or umbels. Stamens usually 3 or 6, anthers adnate, introrse, 2-celled, dehiscing by a slit. Pistil superior, 1-celled or 3-celled, with 3 to many ascending ovules; stigmas 3, filiform. Fruit a loculicidal capsule. Seeds 3 or many, small, cylindric or globose, with or without tail-like appendages.

Leaf-sheaths open; capsule 1-celled or 3-celled, many-seeded. 1. *Juncus*.
Leaf-sheaths closed; capsule 1-celled, 3-seeded. 2. *Juncoides*.

1. JUNCUS L. Sp. Pl. 325. 1753.

Perennials, rarely annual, with scapose or leaf-bearing stems, and usually paniculate or corymbose flowers. Leaf-sheaths with free margins, the leaf-blades terete, sword-shaped, channeled or grass-like. Seed frequently reticulated or ribbed.

*Lowest leaf of the inflorescence terete, scarcely channeled, erect, appearing as a continuation of the naked stem.
  Perianth-parts equaling or exceeding the capsule, all acute; stamens 3. 1. *J. effusus*.
  Perianth-parts about as long as the capsule, acute; stamens 6. 2. *J. balticus*.

**Lowest leaf of the inflorescence not appearing as a continuation of the stem or if so deeply channeled along the upper side.

†Leaf-blade transversely flattened, the surface facing the stem, terete and channeled, without septa.

Flowers bracteolate, inserted singly on the branches of the inflorescence, sometimes clustered.

Leaf-blade flat, sometimes involute in drying; stem leaves none; perianth-parts acute or acuminate. 3. *J. tenuis.*

Leaf-blade terete, channeled along the upper side; seed tailed. 4. *J. vaseyi.*

Flowers not bracteolate, in true heads on branches of the inflorescence.

Stem erect, anthers brownish red; capsule not mucronate. 5. *J. marginatus.*

††Leaf-blade not transversely flattened, usually terete, hollow, with septa.

Stamens 6, opposite the perianth-parts.

Leaf-blades erect; inner perianth-parts longer than the outer. 6. *J. nodosus.*

Leaf-blades abruptly divergent from the stem; outer perianth-parts longer than the inner. 7. *J. torreyi.*

Stamens 3, none opposite the inner perianth-parts.

Seed one-third to one line long. 8. *J. canadensis.*

Seed one-fourth of a line or less in length. 9. *J. acuminatus.*

1. JUNCUS EFFUSUS L. Sp. Pl. 326. 1753.

Rootstock stout, running, branching, proliferous, with brown bracts, 1—2 lines thick; stems 15—50 inches high, striate below the inflorescence, soft; basal leaves rudimentary, filiform; stem leaves none; inflorescence a small congested cluster or else expanded into a panicle which may be 2—4 inches long, lowest bract 2—10 inches long and appearing as a continuation of the stem, other bracts minute; perianth 1—2 lines long, the parts lanceolate, acuminate, green; stamens 3, filaments longer than the anthers; capsule obovoid, 3-celled, dehiscent; seed oblong, oblique, reticulate in about 16 rows. Type locality: "*Habitat in* Europæ *uliginosis.*"

Although this species is widely distributed throughout North America it seems to be rare in Iowa. It was first reported by Professor Arthur in 1876. In 1905 Mr. Cratty reported the species as occurring in Muscatine, Webster and Woodbury counties.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32. 1876.
Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 72, October, 1905.

2. JUNCUS BALTICUS Willd. Berlin Mag. 3: 298. 1809.

Rootstock slender, creeping, 1—2 lines in thickness, horizontal, often a foot or more in length; stems dark green, 10—40 inches high, 1—2 lines thick, arising at intervals in a row from the rootstocks; basal leaves represented by bladeless brown sheaths; panicle 1—3 inches high; perianth 1—3 lines long, the parts lanceolate and usually acute, subequal, brown, with a green midrib and hyaline margins; style a line or less in length; stigmas shorter; stamens 6, shorter than the perianth; anthers less than a line in length and much longer than the filaments; capsule 1—2 lines long, ovoid, mucronate, pale or dark brown, 3-celled; seeds narrowly obovoid or oblong, oblique, about 40-striate.

This species is found in Asia, Europe and America. The range in America is from Labrador to Alaska, southward to southern New York, Ohio, Illinois, Iowa and Wyoming.

The Iowa specimen in the writer's herbarium was collected in Emmet county, June 19, 1904, by R. I. Cratty, who also reports the species from Kossuth and Webster counties. In Iowa the species is quite rare. Iowa specimens were first collected by Mr. Cratty in about the year 1882.

Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences, Vol. 4, p. 28, 1884.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 148, 1884.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904; The Iowa Naturalist, Vol. 1, No. 4, p. 72, October, 1905.

3. JUNCUS TENUIS Willd. Sp. Pl. 2: 214. 1799.

Stems tufted, 6—30 inches high; basal leaves about one-half a line in width, approximately half the length of the stem; stem leaves none; inflorescence 1—4 inches high, its lower leaf 3 or 4 times longer, the upper leaf twice as long; perianth about two lines long, the parts lanceolate, acuminate, divergent, scarious-margined; stamens 6, one line or more long; anthers shorter than the filaments; capsule oblong to obovoid, shorter than the perianth, rounded at the top, partially 3-celled; seeds small, narrowly oblong to obovoid, reticulated in about 16 rows, with oblique ends.

This cosmopolitan species is common in dry soil in grassy or waste places, blooming and developing throughout the summer. Type locality: "*Habitat in* America boreali."

Specimens in the writer's herbarium are from Winneshiek, Johnson, Decatur, Osceola, Union, Pottawattamie, Shelby and Story counties. The species was noted in Allamakee, Dubuque, Jackson, and Emmet counties. The State University herbarium has specimens from the additional counties of Lyon, Dickinson, Cerro Gordo, Hancock, Winnebago, Scott and Linn. Professor Pammel reported the species from Woodbury county; Professor Fink from Fayette county; Barnes, Reppert and Miller from Scott and Muscatine counties; Cratty from Webster, Kossuth, Bremer, Louisa and Iowa counties; and Peck from Hardin county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

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Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 130, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 262, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904; The Iowa Naturalist, Vol. 1, No. 4, p. 72, October, 1905.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

4. JUNCUS VASEYI Engelm. Trans. Acad. Science St. Louis, 2: 448. 1866.

Stems tufted, 10—30 inches high, less than a line in diameter; basal leaves with small auriculate sheaths, the uppermost having a terete channeled blade which is one-half to three-fourths as long as the stem; stem leaves none; inflorescence 1-2 inches or less in height, few-to-many flowered; lowest bract shorter than or exceeding the inflorescence; perianth 1-2 lines long, the parts subulate-lanceolate, margins hyaline; stamens 6, shorter than the perianth; anthers slightly shorter than the filaments; style scarcely any; stigmas short; capsule a little exceeding the perianth, narrowly oblong, truncate or obtuse, mucronate, 3-celled; seed linear-oblong, oblique, 20—24-ribbed, long-tailed.

This species is said to range from Maine and Ontario to Michigan, Illinois, Iowa, on the Saskatchewan, and south in the Rocky Mountains to Colorado. The type locality is: "On the banks of Fox river, near Ringwood, in Northern Illinois."

This species is credited to Clinton county by J. C. Arthur. Its presence in the Iowa flora is not well known.

Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences, Vol. 3, p. 170, 1882.
Britton, N. L. and Brown, A. Illustrated Flora, Vol. 1, p. 386, 1896.
Britton, N. L. Manual, p. 248, 1901.
Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 73, October, 1905.

5. JUNCUS MARGINATUS Rostk. De Junco. Monogr. Junc. 38. pl. 2, f. 3. 1801.

Juncus marginatus var. paucicapitatus Engelm. Trans. Acad. Science, St. Louis, 2: 45[illegible]. 18[illegible].

Rootstocks branching; stems more or less bulbous at the base, erect, 10—20 in[illegible] leaf-sheaths auriculate; the blades a line or less in width, with a well-marked mid-rib and 2—4 conspicuous veins; panicle 1-4 inches high, made up of 2—20 heads which are [illegible] perianth 1—2 lines long, [illegible] obovate, obtuse, the margins hyaline; stamens 3, about the length of the perianth; anthers ovate, [illegible] shorter than the filiform filaments; capsule as long as the perianth, obovoid, truncate or retuse, nearly 3-celled; seeds oblong, 1[illegible]-ribbed, pointed at either end.

Britton and Brown give the range of this species as from Maine to Ontario, south to Florida and Nebraska. The habitat is grassy places. Type locality: "Hab. in Pennsylvania."

The only Iowa locality known for this species is Muscatine county, where it is said to be infrequent.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 262, 1900.
Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 73, October, 1905.

6. JUNCUS NODOSUS L. Sp. Pl. Ed. 2. 466. 1762.

Rootstock slender, nearly scaleless; stems solitary, arising from tuber-like thickenings, 6—30 inches high; leaves both basal and cauline, the blades long, erect, marked by transverse septa, the upper extending beyond the inflorescence; stem leaves 2—4; panicle 1—2 inches long,

shorter than the lowest bract; heads 1—30, spherical, several to many-flowered, 3—6 lines in diameter; perianth 1—2 lines long, the parts lanceolate-subulate, usually reddish brown above, outer shorter than the inner; stamens 6, about one-half the length of the perianth; anthers longer than the filaments; capsule lanceolate-subulate, 3-sided, 1-celled, longer than the perianth; seeds oblong, acute below, apiculate above, reticulate in 20—30 rows. Type locality: "*Habitat in* America *septentrionali.*"

This species ranged from Nova Scotia to British Columbia, south to Virginia, Nebraska, Wyoming and Nevada. It is common throughout Iowa in low wet soil. Specimens at hand are from Fayette county. Professor Pammel reported the species from Woodbury county; Cratty from Emmet, Kossuth, Dickinson, Webster and Cerro Gordo counties; and Peck from Hardin county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 33, 1876.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, p. 134, 1896.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904; The Iowa Naturalist, Vol. 1, No. 4, p. 73, October, 1905.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

7. JUNCUS TORREYI Coville Bull. Torr. Club, 22: 303. 1895.

***Juncus** nodosus* var. *megacephalus* Torr. Fl. N. Y. 2: 326. 1843.

***Juncus** megacephalus* Wood, Bot. Ed. 2, 724. 1861. Not *Juncus megacephalus* M. A. Curtis, 1835.

Rootstock slender, tuberous at intervals; stems 8—40 inches high, stout, 1—4 leaved; blade stout terete, a line or less in thickness, divergent, marked by septa; inflorescence congested, exceeded by the lowest bract; heads 1—20, 5—8 lines in diameter; perianth 2—3 lines long, the parts subulate, the outer longer than the inner; stamens 6, about half the length of the perianth; capsule subulate, 3-sided, 1-celled, with a beak nearly a line in length, exceeding the perianth; seed oblong, acute at both ends, reticulate in about twenty rows.

A species ranging from New England to Oregon, south to Alabama and Texas. Wood's type locality is: "Borders of streams and lakes, New York to Wisconsin, south to Florida." The species is common throughout Iowa in low wet soil.

Specimens in the writer's herbarium are from Linn, Decatur, Fremont and Osceola counties. The species was noted in Emmet, Kossuth, Palo Alto, Humboldt and Wright counties. The State University herbarium has specimens from the additional counties of Woodbury, Lyon, Dickinson, Cerro Gordo, Winnebago and Dallas. Professor Hitchcock reported the species from Story county; Barnes, Reppert and Miller from Scott and Muscatine counties; Cratty from Webster and Fayette counties, and Peck from Hardin county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 33, 1876.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 149, 1884.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 521, 1892.

Shimek, B. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 76, 1897.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 199, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Science, Vol. 8, p. 263, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904; The Iowa Naturalist, Vol. 1, No. 4, p. 73, October, 1905.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

8. JUNCUS CANADENSIS J. Gay; Laharpe, Monogr. Junc. 134. 1825.

Juncus canadensis longicaudatus Engelm. Trans. Acad. Science St. Louis, 2: 474. 1868.

Rootstock branched; stems tufted, 1—4 feet high, stout, basal leaves decaying early; stem leaves with loose auriculate sheaths which are 2—4 inches long, blade stout, erect, 4—10 inches long, marked with septae; panicle 3—10 inches high, branches moderately spreading; heads 5—40-flowered, hemispheric, subspheric, or top-shaped; perianth 1—2 lines long, the parts narrowly lanceolate, acute, the inner longer than the outer; stamens 3, included; filaments long; anthers short; capsule lanceolate in outline, acute, mucronate, 3-sided, 1-celled, reddish-brown, exceeding the perianth; seed less than a line long, tailed at either end, body shining, about 40-striate.

This species ranges from New Brunswick to Minnesota, south to Georgia, Alabama, Louisiana and Arkansas. Type locality: "Hab. in Canada."

Barnes, Reppert and Miller reported this species as infrequent in Muscatine county, and Peck reports it as common in moist open ground in Hardin county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 33, 1876.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 263, 1900.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 74, October, 1905.

9. JUNCUS ACUMINATUS Michx. Fl. Bor. Am. 1: 192. 1803.

Rootstock very short; stems 10—40 inches high, tufted, erect, 1—3 leaved; blades of the lower leaves 4—8 inches long, one line or less in thickness; inflorescence 2—6 inches high, one to many heads, branches spreading; heads hemispheric or subspheric, 3—20-flowered; perianth 1—2 lines long, parts lanceolate-subulate, subequal; stamens 3, one-half as long as the perianth; anthers shorter than the filaments; capsule ovate-lanceolate, broadly acute, mucronate, 1-celled, equaling the perianth; seed oblong, about one-fourth line in length, tipped at both ends, reticulate in 16—20 rows.

A species ranging from Maine to Minnesota, south to Georgia and Mexico. The type locality is: "Hab. in Carolina inferiore."

In Iowa this species is known only from Muscatine county, where it was reported as infrequent by Barnes, Reppert and Miller.

Arthur, J. C. Contributions to the Flora of Iowa, p. 33, 1876.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 262, 1900.

Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 74, October, 1905.

2. JUNCOIDES Adans. Fam. Pl. 2: 47. 1763.

(LUZULA DC. Fl. Fr. 3: 158. 1805.)

Perennial herbs, with leaf-bearing stems, and corymbose paniculate, or umbelloid inflorescence. Leaf-sheaths with united margins; leaf-blades grass-like. Flowers bracteolate, the bractlets lacerate or denticulate; stamens 6; ovary 1-celled, with 3 ovules; seeds three, reticulated.

Inflorescence umbelloid, one or two flowers on each branch. 1. *J. pilosum.*
Inflorescence of 2—12 spike-like or capitate clusters. 2. *J. campestre.*

1. JUNCOIDES PILOSUM (L.) Kuntze.

Juncus pilosus L. Sp. Pl. 329. 1753.
Luzula vernalis DC. Fl. Fr. 3: 160. 1805.
Luzula pilosa Willd. Enum. Pl. 393. 1809.
Juncoides pilosum Kuntze, Rev. Gen. Pl. 725. 1891.

Tufted, sometimes stoloniferous; stems erect, 2—4-leaved, 6—12 inches high; leaf-blades 1—4 lines wide, flat, sometimes webbed, acuminate; inflorescence umbelloid; bract 5—12 lines long; pedicels filiform with one or two flowers; perianth 1—2 lines long, the parts triangular-ovate, acuminate, brown, the margins hyaline, twice as long as the toothed brackets; capsule exceeding the perianth.

A species ranging from New Brunswick to Alaska, south to New York, North Carolina, Michigan and Oregon. Type locality: "*Habitat in* Europæ *sylvis.*"

This species was reported as occurring in moist sandy soil at Wild Cat Den in Muscatine county by Barnes, Reppert and Miller.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 263, 1900.

Cratty, R. I. The Iowa Naturalist, Vol. 1, No. 4, p. 74, October, 1905.

2. JUNCOIDES CAMPESTRE (L.) Kuntze.

Juncus campestris L. Sp. Pl. 329. 1753.
Luzula campestris DC. Fl. Fr. 3: 161. 1805.
Juncoides campestre Kuntze, Rev. Gen. Pl. 2: 722. 1891.

Stems densely tufted, erect, 4—20 inches high, 2—4-leaved; leaf-blades flat, 1—3 lines across, sparingly webbed when young, apex bluntish, gland-like; inflorescence umbelloid; lower bracts leaf-like, branches straight, unequal; spikes dense, oblong to short cylindric; floral bracts ovate, acuminate; bractlets similar, but smaller, fimbriate at the apex; perianth 1—2 lines long, brown, the parts lanceolate-ovate and acuminate; capsule broadly oblong or obovoid; seed with an oblong body.

A woodland species ranging pretty generally throughout the United States and British America. Also found in Europe and Asia. Type locality: "*Habitat in* Europæ *pascuis siccioribus.*"

The only Iowa specimen in the writer's herbarium was collected by R. I. Cratty in Emmet county, June 9, 1882. The species was reported by Professor Arthur from Lee county; by Barnes, Reppert and Miller from Muscatine county; and by Cratty from Dubuque county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 148, 1884.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 263, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, p. 215, 1904; The Iowa Naturalist, Vol. 1, No. 4, p. 74, October, 1905.

2. MELANTHACEAE R. Br. Prodr. 1: 272. 1810.

Bunch-flower Family.

This family of plants of wide distribution, comprising nearly forty genera and about one hundred and forty species, has in North America, north of Mexico, about nineteen genera and over fifty species. Of these four genera and five species are found in Iowa. The Melanthaceae are usually included with the Liliaceae from which they are separated by having the capsules mostly septicidal and the plants rarely from bulbs. The characters are:

Leafy-stemmed herbs with rootstocks or bulbs, grass-like parallel-veined leaves, and perfect, polygamous, or dioecious flowers. Perianth of six separate or nearly separate segments. Stamens six, borne on the bases of the perianth-segments. Anthers small, 2-celled, oblong or ovate, or confluently 1-celled and reniform or cordate. Ovary 3-celled, usually superior; ovules few or many. Styles 3, distinct, or somewhat united. Fruit a capsule with septicidal or rarely loculicidal dehiscence. Seeds frequently with tails or appendages.

Flowers numerous in terminal erect racemes or panicles.
  Plants glabrous.
    Perianth segments bearing glands. 1. *Zigadenus.*
  Plant with stem and inflorescence pubescent.
    Perianth-segments with claws, free from the ovary. 2. *Melanthium.*
    Perianth-segments without claws, adnate to the base of the ovary. 3. *Veratrum.*
Flowers solitary, [illegible] the leaves, drooping. 4. *Uvularia.*

1. Z[illegible]DENUS [illegible] Fl. Bor. Am. 1: 213. 1303.

Erect per[illegible] or bulbs, leafy stems, narrow line[illegible] to whitish, paniculate or r[illegible], withering. Stamens 6, free, abor[illegible] anthers cordate or reniform. Cap[illegible] ending, close together, dehis[illegible] few or many.

1. Z[illegible] 1: 241. 1814. Glaucous [illegible].

Mel[illegible] [illegible]
Zyga[illegible] Nutt. [illegible]

Plant from [illegible] in height, [illegible] glaucous, from an ovoid membran[illegible]; stem slender, simple; leaves narrowly [illegible] long and a half inch or less in width, the [illegible] in length; bracts conspicuous, lanceolate, purplish or green, inflorescence in a raceme or panicle, 6—12 inches long, open, the branches slender and ascending; flowers greenish, 8—10 lines broad; perianth-segments oval to obovate, obtuse, short-clawed, united below and adnate to the base of the ovary, each with a solitary large obcordate gland above the claw; capsule oblong, nearly one inch in length, exceeding the perianth.

This plant grows in moist rich soil, in grassy or open places, blooming during June and July. The plant has a wide range, extending from New Brunswick to Alaska, southward to New York, Missouri and Mexico. Type locality: "On the waters of Cokahlaishkit river, near the Rocky Mountains."

Iowa specimens in the writer's herbarium are from Winneshiek, Allamakee, Emmet, Osceola and Lyon counties. The species is quite common in the northern portion of the state, but appears to be absent in the central and southern portions. The writer once reported the species from Decatur county as a result of an error in determination. Mr. Peck has reported the species from Hardin county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, p. 134, 1896; Vol. 9, 1901, p. 177, 1902.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898; Iowa Naturalist, Vol. 1, No. 1, pp. 8—9, August, 1904; Vol. 1, No. 4, p. 76, October, 1905; Plant World, Vol. 7, No. 9, pp. 221—222, September, 1904; The Melanthaceae of Iowa, p. 2, December, 1905.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1898, Vol. 6, p. 198, 1899.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. MELANTHIUM L. Sp. Pl. 339. 1753.

Tall perennial herbs with thick rootstocks, leafy pubescent stems, oval to linear mostly sheathing leaves, and monoecious or polygamous greenish, white or cream colored paniculate flowers. Perianth of six spreading segments, persistent, distinct, free from the ovary. Stamens adnate to the segments and shorter, the anthers cordate or reniform, the sacs confluent. Ovary ovoid with three subulate spreading styles. Capsule 3-lobed, 3-celled, the cavities septicidal, tipped by the remaining styles. Seeds flat, broadly winged.

1. MELANTHIUM VIRGINICUM L. Sp. Pl. 339. 1753. Bunch-flower.

Stem stout 5—6 feet high; leaves linear, 6—18 inches long, 4—12 lines wide, acute, the lower sheathing, the upper smaller and sessile; panicle 1—2 feet long, dense, pubescent, the branches ascending; pedicels about one inch in length; bracts ovate-oblong, shorter than the pedicels; flowers one-half inch to an inch across, greenish yellow, turning to brown, perianth-segments obtuse, the blade oblong, flat, entire, about twice the length of the claw, frequently obcordate, with two dark glands at the base; capsule about one-half inch in length; the styles 1—2 lines long, persistent, erect; seeds 2—3 lines long, 8—10 in each cavity. The type locality is: "*Habitat in* Virginia."

This rather showy plant is of infrequent occurrence in low moist meadows and prairies, blooming for the most part in July and August. Specimens at hand are from Johnson, Lee, Decatur, Adams and Union counties. Additional specimens in the State University herbarium are

from Hancock and Cerro Gordo counties. The writer has observed the species growing in Linn, Benton, Tama, Iowa, Poweshiek and Jasper counties. Gow has reported the species from Adair county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Shimek, B. Bulletin from the Laboratory of Natural History of the State University of Iowa, Vol. 3, part 2, p. 213, 1896.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Fitzpatrick, T. J. The Iowa Naturalist, Vol. 1, No. 4, p. 76, October, 1905; The Melanthaceae of Iowa, p. 4, December, 1905.

3. VERATRUM L. Sp. Pl. 1044. 1753.

Tall herbs, with short thick rootstocks, strongly veined and clasping leaves, and greenish, yellowish or purplish, monoecious or polygamous flowers displayed in large terminal panicles. Perianth-segments 6, glandless or nearly so, without claws, adnate to the base of the ovary. Stamens 6, free from the perianth-segments but opposite them. Anthers cordate, the sacs confluent. Ovary ovoid; styles 3, persistent. Capsule 3-lobed, 3-celled, the cavities several-seeded. Seeds flat, broadly winged.

1. VERATRUM WOODII Robbins in Wood, Classbook, Ed. 10. 557, 1850. Wood's False Hellebore.

Plant from a short erect poisonous rootstock which is covered with a shaggy fibrous coat formed from the remains of decayed leaves; rootlets slender, many, with a hard fibrous center; stem 2—6 feet high, slender, pubescent; leaves mostly from below, oblong, lanceolate, or oblanceolate, entire, glabrous, acute, 5—12 inches long, 2—4 inches wide; the upper leaves small, linear-lanceolate; panicle simple, 1—2 feet long, pyramidal, open, pubescent, the branches ascending; pedicels and bracts of about equal length, shorter than the perianth; flowers about one-half inch across, purple; perianth-segments oblanceolate, obtuse, nearly glabrous, slightly exceeding the stamens in length; ovary pubescent when young, glabrous when mature; capsule about one-half inch in length, with a few seeds. The type locality is: "Woods, Linton, Green Co., I[ndian]a!"

This plant occurs in dry soil in open woods, frequently solitary, sometimes in colonies. The flowers open during July. The species ranges from Indiana to Missouri, and is found in Iowa only in the southern counties where it is of frequent occurrence. Apparently it rarely blooms as the vast majority of the plants found by the writer, consisted only of the rootstocks and the radical leaves.

Specimens at hand are from Jefferson, Appanoose and Decatur counties. J. C. Arthur reported the species from Des Moines county and L. H. Pammel from Wayne and Wapello counties.

Wood, A. Bulletin of the Torrey Botanical Club, Vol. 6, Nos. 43-44, p. 245, July-August, 1878.

Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences Vol. 3, p. 170, 1882.

Pammel, L. H. The Plant World, Vol. 4, No. 8, pp. 151—152, August, 1901.

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Fitzpatrick, T. J. The Iowa Naturalist, Vol. 1, No. 4, p. 78, October. 1905 *The Melanthaceae* of Iowa, p. 5, December, 1905.

4. UVULARIA L. Sp. Pl. 304. 1753.

Erect forked perennial herbs, with alternate sessile or perfoliate leaves, and large peduncled drooping usually solitary flowers. Perianth narrow or campanulate; its segments distinct, deciduous, each with a nectary at the base. Stamens 6, free or adnate to the bases of the perianth-segments; filaments slender; anthers linear, the sacs longitudinally dehiscent. Ovary 3-lobed, 3-celled, sessile or short-stalked, with several ovules in each cell; styles 3, united to near the middle, stigmatic along the inide. Capsule ovoid or obovoid, 3-angled or 3-winged, loculicidally dehiscent. Seeds globose, 1—3 in each cell.

Leaves perfoliate; capsule obtusely 3-angled.
 Leaves pubescent beneath; perianth-segments smooth. 1. *U. grandiflora.*
 Plant glabrous and glaucous; perianth-segments papillose within. 2. *U. perfoliata.*
Leaves sessile; capsule acutely 3 angled or 3-winged. 3. *U. sessilifolia.*

1. Uvularia grandiflora J. E. Smith, Ex. Bot. 1; 99, Pl. 51. 1804-5. Large-flowered Bellwort.

Stem 6—20 inches high, scale bearing below, naked or with one or two leaves below the fork; roots many, long and slender; leaves perfoliate, oval, ovate or oblong, apex acute, base rounded or acutish, pubescent beneath, sometimes becoming glabrate, glabrous above; flowers lemon-yellow, an inch or more in length; perianth-segments smooth, sometimes slightly granular within; stamens longer than the styles; connective blunt; capsule truncate, 3-angled, 4—5 lines long, dehiscent above, on a peduncle an inch in length. Type locality: "Received from North America."

This Bellwort is frequent in rich woods. The flowers appear during the latter part of April and early May, many appearing later in May; the fruit ripens in June. The species ranges from New Brunswick and Ontario to Minnesota, south to Georgia, Alabama, Tennessee and Iowa. In Iowa the species is well distributed throughout the state. Specimens at hand are from Winneshiek, Muscatine, Johnson, Appanoose and Decatur counties. The writer noted the species in Allamakee and Clayton counties. Specimens examined in the State University herbarium were from the additional counties of Lee, Dallas, Calhoun, Cerro Gordo, Winnebago and Emmet. J. C. Arthur reported the species from Story county; L. H. Pammel from Woodbury county; Bruce Fink from Fayette county; Barnes, Reppert and Miller from Scott county; James. Gow from Adair county; and Peck from Hardin county.

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Britton, N. L. Manual, p. 260, 1901.
Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.
Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.
Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. Uvularia perfoliata L. Sp. Pl. 304. 1753. Perfolite Bellwort.

Plant glabrous, glaucous or pale green; stems 6—20 inches high, slender, with 1—3 leaves below the fork; leaves ovate-lanceolate, oblong, or oval, margin smooth, apex acute, base rounded or narrowed; flowers pale yellow, 10—15 lines long; perianth-segments glandulose papillose within; stamens shorter or equaling the styles, connective acute; capsule obovoid, truncate, 4—5 lines long, thicker, obtusely 3-angled, the sides concave and the angles grooved, the lobes dehiscent above. The type locality is: "*Habitat in* Virginia, Canada."

This plant occurs in moist woods. The range as given by Britton and Brown is "Quebec and Ontario to Florida and Mississippi". Conway MacMillan in "Metaspermae of the Minnesota Valley" gives the western range as Minnesota, Dakota and Missouri. Iowa is thus within the range and the species should occur. Occasionally it has been reported, but all reputed specimens so far examined have proven to be the preceding species.

Flores. Iowa Farmer and Horticulturist, Vol. 1, p. 30, 1853.
Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.
Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.
Fitzpatrick, T. J. The Iowa Naturalist, Vol. 1, No. 4, p. 80, October, 1905; The Melanthaceae of Iowa, p. 7, December, 1905.

3. Uvularia sessilifolia L. Sp. Pl. 305. 1753. Sessile-leaved Bellwort.

Oakesia sessilifolia S. Watson. Proc. Am. Acad. 14: 269. 1879.

Stem 6—16 inches high, naked and with scales below, leafy above, glabrous, 1—2 leaves below the fork; leaves sessile, thin, 1—3 inches long, acute at each end, rough-margined, pale or glaucous beneath; flowers yellow, somewhat greenish, 8—16 lines long; perianth-segments smooth; stamens shorter than the styles; anthers obtuse; capsule acutely 3-angled, narrowed at each end, about one inch long, 6—8 lines wide, short-stipitate, on a peduncle one-half to one inch in length. The type locality is: "*Habitat in* Canada."

This species occurs in rich moist woods from New Brunswick and Ontario to Minnesota, south to Georgia, Alabama and Arkansas. In Iowa it blooms in April and May and appears to be infrequent.

The only Iowa specimen at hand was collected in Johnson county, April, 1883. The writer has seen specimens from Winneshiek and Des Moines counties. J. C. Arthur reported the species from Benton county; Bruce Fink from Fayette county, and F. Reppert from Muscatine county.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa, and Minnesota, p. 620, 1852.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences, Vol. 2, p. 259, 1878.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898; The Iowa Naturalist, Vol. 1, No. 4, p. 81, October, 1905; The Melanthaceae of Iowa, p. 8, December, 1905.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

3. LILIACEAE Adans. Fam. Pl. 42. 1763.

LILY FAMILY.

Scapose or leafy-stemmed herbs from bulbs or corms, with linear, lanceolate, or ovate leaves, and solitary or clustered, regular, usually perfect flowers. Perianth of six separate or slightly united segments. Stamens 6, hypogynous or borne on the perianth-segments; anthers 2-celled, introrse, sometimes extrorse. Ovary 3-celled; ovules few or many in each cell; style one; stigma capitate or 3-lobed. Fruit usually a loculicidal capsule; seeds winged or wingless.

Plants with thick fibrous fleshy roots; scape tall. 1. *Hemerocallis.*
Plants with bulbs or corms.
  Flowers umbelled; odor onion-like. 2. *Allium.*
  Flowers solitary, racemed, corymbed, or panicled.
    Anthers not introrse; perianth-segments all alike or nearly so.
      Anthers versatile; tall herbs. 3. *Lilium.*
      Anthers not versatile; low herbs. 4. *Erythronium.*
    Anthers introrse; segments separate; filaments filiform. 5. *Quamasia.*
Stem with a woody caudex; leaves rigid, bearing marginal fibers. 6. *Yucca.*

1. HEMEROCALLIS FULVA L. Sp. Pl. Ed. 2: 462. 1762. Day Lily.

Roots fibrous, fleshy thickened, appearing tuberous; scapes 3—6 feet high, hollow, angled, with a few short bracts above, the base appearing fibrous coated due to the decaying leaves; leaves linear, 4—14 lines wide, 10—30 inches long, channeled above, carinate below; flowers 6—15, tawny yellow, on pedicels which are 3—6 lines long, panicled, ephemeral, 4—5 inches long; tube of the perianth 10—18 lines long; perianth funnelform; the lobes oblong, netted-veined, spreading, the three outer nearly flat, acutish, the three inner undulate, bluntish; stamens 6, inserted at the summit of the perianth tube, shorter than the lobes, declined; filaments

slender; anthers linear-oblong, the sacs introrsely-dehiscent; ovary oblong, 3-celled; ovules many; style slender, declined, equaling or exceeding the perianth-segments; stigma small, capitate; capsule oblong or ovoid, 3-angled, thick-walled, transversely wrinkled, loculicidally 3-valved. The type locality is: "*Habitat in* China."

Plant frequent in cultivation and becoming an escape. Blooms from June until August.

Specimens as escapes were collected by the writer in Dubuque and Johnson counties.

2. ALLIUM L. Sp. Pl. 294. 1753.

Herbs, with characteristic odor, solitary or clustered bulbs on short rootstocks, narrow linear or sometimes oblong or lanceolate sheathing basal or rarely cauline leaves, and white, pink, or purple flowers in a terminal umbel which is subtended by 2 or 3 membranous bracts. Scape or stem simple, erect. Pedicels slender. Perianth persistent; segments 6, separate or united below, the stamens inserted on their bases. Filaments filiform or dilated, occasionally toothed; anther-sacs introrsely dehiscent. Ovary sessile or nearly so, 3-celled or partially so; style filiform, jointed, usually deciduous; stigmas small; ovules 1—6 in each cell. Capsule loculicidal.

Leaves oblong-lanceolate, soon perishing. 1. *A. tricoccum.*
Leaves linear, present at flowering time.
  ulb coats membranous, not fibrous-reticulated.
    Flowehing umbel nodding. 2. *A. cernuum.*
    Flowering umbel erect. 3. *A. stellatum.*
  Bulb-coats fibrous-reticulated. 4. *A. canadense.*

1. ALLIUM TRICOCCUM Aiton, Hort. Kew. 1: 428. 1789. Wild Leek.

Rootstock short; rootlets many, slender; bulbs usually clustered, ovoid, 1—2 inches high, with fibrous reticulated coats; leaves 2 or 3, appearing in April and May, soon withering, oblong-lanceolate or elliptic, acute or acuminate, base tapering to long petioles, thin, blades 5—12 inches long, 1—3 inches wide, bases of petioles sheathing; scapes 5—14 inches high; bracts usually 2, at first enfolding the umbel, membranous, acuminate deciduous; flowers 10—30, erect, appearing in June and July; pedicels slender, thickened in fruit, 6—10 lines long; flowers white; perianth-segments oblong, obtuse, 2—3 lines long; filaments lanceolate-subulate, about equaling the perianth; ovary 3-celled, with one ovule in each cell; capsule deeply 3-lobed, 2 lines or less in height, 3 lines broad; seeds globose, smooth, black.

This species occurs in rich woods from New Brunswick to Minnesota, south to North Carolina, Tennessee and Missouri. The plants sometimes occur singly, but usually clustered into a considerable bed. In Iowa the species is frequently met with in the eastern portion of the state, but becomes rarer northward and westward.

Specimens in the writer's collection are from Winneshiek, Allamakee, Jones, Johnson, Decatur and Emmet counties. Professor Fink reported the species from Fayette county; Professor Bessey from Story county; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 147, 1884.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. ALLIUM CERNUUM Roth; Roem. Arch. 1: Part 3, 40. 1798. Nodding Wild Onion.

Bulbs narrowly ovoid, tapering above into a neck 1—2 inches long, usually clustered on a short rootstock, with membranous coats; scapes 1—2 feet high, slender, faintly ridged; leaves linear, flat or channeled, 1—2 lines wide, nearly or quite as long as the scape, bluntish; umbel nodding, 15—30-flowered, subtended by two short deciduous bracts; pedicels filiform, 8—15 lines long; flowers white or rose, sometimes purplish; perianth segments ovate-oblong, acute or obtusish, 2—3 lines long; stamens exserted; filaments slender; ovary 3-celled, with two ovules in each cell; capsule 3-lobed, included in the perianth, each valve with two processes near the summit.

This species is said to range from New York to Minnesota, South Dakota, south in the mountains to South Carolina and New Mexico. The habitat is banks and hillsides. The flowers appear in July and August. In Iowa the species seems limited to the northern half of the state. In Emmet county the writer found the species common on the prairies. Professor Arthur reported the species from Plymouth and Winneshiek counties and the State University herbarium has specimens from Dickinson and Lyon counties. The writer also has a specimen collected in Winneshiek county.

Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences, Vol. 3, p. 170, 1882.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

3. ALLIUM STELLATUM Ker. Bot. Mag. pl. 1576. 1813. Prairie Wild Onion.

Bulbs solitary or clustered, narrowly ovoid, 1—2 inches long, coats membranous; scape slender, 8—30 inches high, slightly ridged near the summit; leaves linear, about one line in width, nearly flat; umbel 10—30-flowered, erect, subtended by two ovate or lanceolate acuminate bracts; pedicels slender, 6—10 lines long; flowers rose-color; perianth-segments ovate-oblong, acute, 2—3 lines long; filaments slender, equaling or exceeding the perianth; capsule shorter than the perianth, 3-lobed, with about six seeds, each valve with two processes or crests near the apex.

This species is said to range from Illinois to Minnesota, south to Missouri and Kansas. The flowers open in July and August. In Iowa the species is rather infrequent near the northern border, preferring gravelly prairie soil. Species in the writer's herbarium have been collected in Kossuth, Emmet and Osceola counties. Professor Pammel reported the species as common on prairies at Alton in Sioux county.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, p. 133, 1896.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

4. ALLIUM CANADENSE L. Sp. Pl. 1195. 1753. Meadow Garlic.

Bulbs solitary, ovoid, one inch or less in height, the outer coats fibrous-reticulated; scape terete, 8—28 inches high; leaves basal or nearly so, linear, about a line in width, 6—20 inches long, flat or flattish above, slightly convex beneath, usually shorter than the scape; bracts of the umbel 2 or 3, broadly ovate, white, acuminate; flowers frequently replaced by ovoid bulblets; pedicels slender, one-half to one inch in length; flowers white or pink, the perianth-segments oblong-lanceolate, acute; stamens but little if any exceeding the perianth; filaments widened at the base, without teeth; valves of the capsule not crested.

A species of moist thickets and grassy open places, ranging from Maine to Minnesota, south to Florida, Alabama, Louisiana and Arkansas, becoming in many places a pestulant weed in pastures. The flowers open in May and June. The type locality is: "*Habitat in* Canada."

In Iowa the species is frequent and widely distributed. Specimens in the writer's herbarium are from Winneshiek, Allamakee, Johnson, Decatur, Union, Shelby and Lyon counties. The State University herbarium has specimens from the additional counties of Story, Emmet, Calhoun, Cerro Gordo and Linn counties. Professor Pammel reported the species from Woodbury county; Professor Fink from Fayette county; Barnes, Reppert and Miller from Scott and Muscatine counties; Gow from Adair county; and Peck from Hardin county. The species also occurs in Henry, Dubuque and Dickinson counties.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, p. 133, 1896.

Rigg, G. B. Notes on the Flora of Calhoun county, Iowa, p. 26, 1896.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Shimek, B. Iowa Geological Survey, Vol. 10, p. 178, 1900.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

3. LILIUM L. Sp. Pl. 302. 1753.

Bulbous herbs, with simple leafy stems, and large erect or drooping showy flowers. Flowers funnelform or campanulate; the segments 6, separate, spreading or recurved, deciduous, each with a nectar-bearing groove inside next the base. Stamens 6, usually shorter than the segments, hypogynous, slightly attached to the segments; filaments slender or subulate; anthers linear, versatile, the sacs longitudinally dehiscent. Ovary 3-celled; ovules many; style long, slightly club-shaped above; stigma 3-lobed. Capsule obovoid or oblong, loculicidally dehiscent. Seeds many, flat, arranged horizontally in two rows in each cavity.

Flower or flowers erect; perianth-segments narrowed into long claws.
  Leaves narrowly lanceolate or linear, mostly alternate. 1. *L. lanceolatum.*
Flowers drooping or spreading; perianth-segments not clawed.
  Leaves mostly verticillate, native species.
    Leaves finely roughened on the veins beneath. 2. *L. canadense.*
    Leaves perfectly smooth. 3. *L. superbum.*
  Leaves alternate, the axils bulbiferous, garden escapes. 4. *L. tigrinum.*

1. Lillium lanceolatum new species.

Bulb varying from one-half an inch to an inch in diameter, made up of flattish scales; stem 10—30 inches high, slender, frequently somewhat glaucous; leaves sessile, narrowly lanceolate to nearly linear, alternate or scattered, a few of the upper verticillate, tapering both ways, apex bluntish, margins smooth, usually 2—3 inches long and 2—4 lines wide; flowers usually solitary or two or three and of a reddish orange color, peduncled; perianth-segments ovate, spotted below, long-clawed; stamens included, filaments slender; style exceeding the stamens but shorter than the perianth-segments; capsule about two inches long, oblong in outline.

The type specimen was collected in Decatur county, June 7, 1896. The species grows in rather dry prairie soil, being solitary, but rather frequent in occurrence. Strange as it may appear this species has passed

for *Lilium philadelphicum* L., from which it differs by having alternate narrower leaves, and an oblong capsule. It, however, has many resemblances to *Lilium umbellatum* Pursh, but differs in having wider leaves which are smooth-margined and a much shorter capsule.

Specimens referred to *Lilium lanceolatum* have been collected in Decatur, Adams, Union, Winneshiek, Shelby, Johnson and Osceola counties. The species is fairly constant in its characters. The specimen from Winneshiek county has very narrow leaves, about a line in width, and would pass for *Lilium umbellatum* Pursh so far as that character is concerned. The width of the leaves of most specimens is between three and four lines. In some specimens the leaves are numerous and present a crowded appearance, in other specimens the leaves are much less numerous and distant. In a Shelby county specimen the perianth-segments are narrowly ovate. Only one whorl of leaves occurs in the specimens and that at or near the summit of the stem and it is composed of from 4—8 leaves, but the whorl is frequently absent.

It is doubtful if *Lilium philadelphicum* L. occurs in Iowa, although it is so credited by many writers on the Iowa flora. The range as given by Britton and Brown is from Maine to Ontario, south to North Carolina and Virginia. This seems to exclude Iowa. The same authority states that *Lilium umbellatum* Pursh occurs from Ohio to Minnesota and the northwest territory, south to Missouri, Arkansas and Colorado. If this be correctly stated it is fair to presume that the species may occur in Iowa.

The description of *Lilium philadelphicum* L. in Gray's Manual, 6th edition, includes at least three species among which is the *Lilium lanceolatum* here proposed as new, also *Lilium umbellatum* Pursh, and *Lilium philadelphicum* L. The composite character of the description in Gray's Manual has led all the writers on the Iowa flora to refer the species here discussed to *Lilium philadelphicum* L., as the following list of references show.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Flores. Iowa Farmer and Horticulturist, Vol. 1, No. 3, p. 47, July, 1853.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 146, 1884.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; Vol. 3, 1895, p. 134, 1896.

Rigg, G. B. Notes on the Flora of Calhoun County, Iowa, p. 27, 1896.

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Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. LILIUM CANADENSIS L. Sp. Pl. 303. 1753. Wild Yellow Lily. Canada Lily.

Bulbs 1—2 inches in diameter, subglobose, made up of many thick white scales, borne on a stout rootstock; stem 2—5 feet high, slender or stout; leaves verticillate in 4's to 10's, usually a few alternate, lanceolate or oblong-lanceolate, acuminate, tapering to the base, 2—6 inches long, 3—15 lines wide, finely roughened on the margins and on the veins beneath; flowers on long peduncles, 1—16, nodding, the peduncles occasionally with a leaf-like bract; perianth-segments 2—3 inches long, yellow or red, recurved or spreading, not clawed, usually thickly spotted below; capsule oblong, erect, between one and two inches long. The type locality is: "*Habitat in* Canada."

This species is reported to range from Nova Scotia to Ontario and Minnesota, south to Georgia, Alabama and Missouri. In Iowa the species may be said to be infrequent, though occasionally it is frequent locally. It is fairly well distributed throughout the State. The flowers appear in June and July. The prevailing habitat is low moist prairie soil, but the species may be found in meadows along borders or sometimes in open woods. In some counties the species seem to thrive in the undisturbed prairie soil along the railways.

Specimens in the writer's herbarium are from Winneshiek, Johnson, Jefferson, Appanoose, Decatur and Emmet counties. The species was noted in Muscatine, Montgomery, Palo Alto, Kossuth, Wright, Hardin, Grundy, Tama, Benton and Linn counties. The State University herbarium has specimens from the additional counties of Lee, Chickasaw, Fremont and Page counties. Professor Pammel reported the species from Woodbury county; Professor Fink from Fayette county; Professor Hitchcock from Story county; and Barnes, Reppert and Miller from Scott county.

Flores. Iowa Farmer and Horticulturist, Vol. 1, No. 4, p. 63, August, 1853.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; Vol. 3, 1895, p. 134, 1896.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 130, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

3. LILIUM SUPERBUM L. Sp. Pl. Ed. 2, 434. 1762. Turk's-cap Lily.

This species closely resembles some forms of *Lilium canadense* L. It differs mainly in having the lanceolate or linear-lanceolate leaves very smooth on both surfaces. There are usually many flowers arrayed in a large open panicle.

The species is stated to range from Maine to Ontario and Minnesota, south to North Carolina and Tennessee. The flowers appear in July and August. The habitat is moist soil in open woods or grassy places. The type locality is: "*Habitat in* America *septentrionali.*"

In Iowa the species seems to be rare or at best infrequent. Specimens in the writer's herbarium are from Emmet, Johnson and Montgomery counties. The species was reported from Hesper, Winneshiek county, Iowa, by Mr. Upham. Professor Hitchcock reported finding a few specimens at Jewel Junction, Hamilton county. Professor Bessey gave the following stations: Ames, Story county; Charles City, Floyd county; and Burlington, Des Moines county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Upham, Warren. Catalogue of the Flora of Minnesota, p. 146, 1884.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

4. LILIUM TIGRINUM Andr. Bot. Rep. 9: errata. 1809.

Bulb globose, solitary, an inch or more in diameter; scales many, appressed, oblong-lanceolate; stem stout, purple or blackish, white-pubescent above, 2—5 feet high, leafy throughout or nearly so; leaves lanceolate, alternate, glabrous or somewhat pubescent, 2—6 inches long, one-half to nearly one inch in width, the upper axils bearing blackish bulblets which are made up of three or four scales; flowers few to many, orange red, nodding; the segments lanceolate, papillose, recurved, purple-spotted.

This is with us a species frequent in cultivation, but it is occasionally to be found as an escape along waysides and in waste places.

The writer collected specimens of this species in Fremont county, Iowa, July 29, 1898, where it was a frequent escape by the waysides. Mr. Miller reports the species as a garden escape in Madison county.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1898, Vol. 6, p. 198, 1899.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

4. ERYTHRONIUM L. Sp. Pl. 305. 1753.

Low herbs, from deep membranous coated corms which frequently bear offshoots, with simple steams bearing a pair of unequal leaves near or below the middle, thus appearing basal, and large, nodding, bractless, usually solitary flowers. Many plants consist only of a simple long-petioled leaf from the deep-seated corm. Perianth-segments separate, oblong, lanceolate, or oblanceolate, deciduous, with a nectariferous groove and sometimes two short processes at the base. Stamens 6, hypogynous, included; anthers linear-oblong, not versatile. Ovary sessile, 3-celled; ovules several or numerous in each cell; style slender or thickened above, 3-lobed or 3-cleft. Capsule oblong or obovoid, more or less 3-angled, loculicidal. Seeds compressed or somewhat angled or swollen.

Offshoots produced from the base of the corm; perianth-segments recurved.
Flowers yellow; stigmas very short. 1. *E. americanum.*
Flowers white, blue or purple; stigmas 1—2 lines long, recurved. 2. *E. albidum.*
No offshoots, propagating by basal corms; perianth-segments not recurved. 3. *E. mesochoreum.*

1. Erythronium americanum Ker, Bot. Mag. 27. pl. 1113. June 1, 1808. Yellow Adder's tongue.

Erythronium dens-canis Michx. Fl. Bor. Am. 1: 198. 1803. Not L.
Erythronium angustatum Raf. Med. Rep. (II.) 5: 354. July 20, 1808.
Erythronium bracteatum Bigelow; Beck, Bot. N. & Mid. States, 365. 1833.

Corm ovoid, 5—10 lines high, producing offshoots from the base; stem 6—12 inches high; leaves oblong to oblong-lanceolate, 3—8 inches long, 6—20 lines wide, acute or acuminate, frequently mottled with brown, with clasping petioles; peduncle nearly as long as the leaves, usually bractless; flower yellow, occasionally with a purplish tinge; perianth-segments oblong, 1—2 inches long, 3—4 lines wide, recurved, dotted inside, the three inner auricled at the base; style club-shaped; stigmas mere ridges; capsule obovoid, 6—10 lines high, short-stipitate; seeds curved, backs roundish, between one and two lines long, pointed at both ends. Type locality of *E. dens-canis* Michx: "*Hab.* in frigidioribus Amercia septentrionalis."

Britton and Brown state that this species occurs in moist woods and thickets, ranging from Nova Scotia to Ontario and Minnesota, south to Florida, Missouri and Arkansas. The time of blooming is from March until May.

The writer has seen no specimens credited to Iowa. Professor Bessey reported the species from Fayette county. Professor Arthur credits the species to Winneshiek county, and Mr. Upham states that the species is plentiful locally near Hesper, Winneshiek county, Iowa. Mr. Gow reported the species from Adair county, doubtless an error in determination.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.
Arthur, J. C. Proceedings of the Davenport Academy of Natural Sciences, Vol. 3, p. 170, 1882.
Upham, Warren. Catalogue of the Flora of Minnesota, p. 146, 1884.
Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

2. ERYTHRONIUM ALBIDUM Nutt. Gen. 1: 223. 1818. White Adder's tongue.

Corm ovoid, 5—10 lines high, producing offshoots from its base; stem 5—12 inches long, about one-half of it subterranean; leaves two, from near the middle of the stem, apparently basal, unequal, oblong or oblong-lanceolate, acute, mottled or green all over, base tapering into long clasping petioles; flowers white, frequently tinged with blue or purple, on peduncles as long as the leaves; perianth-segments oblong, recurved, not auricled; stigmas linear, becoming recurved, between one and two lines long; capsule oblong or obovoid, 5—9 lines high. Many plants are flowerless consisting of a single leaf with a rather longer petiole.

This plant grows in moist woods and thickets, flowering from March until May. It ranges from Ontario to Minnesota, south to Georgia, Tennessee and Texas. In Iowa the species is quite common and well distributed.

Specimens in the writer's herbarium are from Johnson, Decatur, Shelby, and Emmet counties. The writer has observed the species growing in Winneshiek, Van Buren and Page counties. The State University herbarium has specimens from Chickasaw, Linn, Polk, Mahaska, Calhoun and Pottawattamie counties. Professor Pammel reported the species from Woodbury county; Professor Fink from Fayette county; Professor Bessey from Fayette, Story, Poweshiek, Des Moines and Warren counties; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 123, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

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Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 2, p. 135, 1877.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; Vol. 3, 1895, p. 134, 1896.

Rigg, G. B. Notes on the Flora of Calhoun County, Iowa, p. 27, 1896.

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Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

3. ERYTHRONIUM MESOCHOREUM Knerr. Midland College Monthly, 2: 5. 1891.

Corm ovoid, 5—10 lines high, producing no offshoots, the new corm forming at or within the base of the old one; stems 4—12 inches high, leaves linear-oblong or narrowly oblong, not mottled, 4—10 inches long, 3—12 lines wide, more or less folded: flowers white, with a lavender tint, 1—2 inches long; perianth-segments not recurved; style slender, stigmas recurved; capsule obovoid, 6—18 lines high.

This plant grows on upland prairie soil. The writer collected this species at various times in Decatur county, Iowa, and Harrison county, Missouri. In these localities the species was very common. Flowering specimens were found as early as the tenth of March and none were collected in April. No flowerless forms were seen. The species also occurs in Nebraska and Kansas.

Britton, N. L. and Brown, A. Illustrated Flora, Vol. 1, p. 421, 1896.
Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1898, Vol. 6, p. 198, 1899.
Britton, N. L. Manual, p. 267, 1901.

5. QUAMASIA Raf. Am. Mon. Mag. 2: 265. 1818.

Scapose herbs, with membranous-coated bulbs, with linear basal leaves, and blue, purple, or whitish bracted flowers disposed in a terminal raceme. Perianth-segments six, separate, equal, spreading, 3—7-nerved, persistent. Pedicels with a joint at the base of the flower. Stamens with filiform filaments which are inserted at the bases of the perianth-segments; anthers oblong to linear-oblong, versatile, introrse. Ovary sessile, 3-celled; ovules many; style filiform, stigma 3-lobed. Capsule oval, 3-angled, loculicidal, with shining black seeds.

1. QUAMASIA ESCULENTA (Ker-Gawl.) Coville. Wild Hyacinth.

Scilla esculenta Ker-Gawl. Bot. Mag. 38. t. 1574. 1813.
Phalengium esculentum Nutt.: Ker-Gawl. Bot. Mag. 38, t. 1574. 1813. As synonym.
Lemotrys hyacinthina Raf. Fl. Tell. 3: 51. 1836.
Scilla fraseri A. Gray, Man. Ed. 2, 469. 1856.
Camassia fraseri Torr. Pac. R. R. Rep. 4: 147. 1857.
Quamasia hyacinthina Britton in Britt. and Brown Ill. Fl. 1: 423. 1896.
Quamasia esculenta Coville, Proc. Biol. Soc. Wash. 11: 65. 1897.

Bulb ovoid, edible, one to two inches long, outer coat blackish; scape 1—2 feet high, slender, occasionally bearing one or two short linear scabrous leaves; basal leaves narrowly linear, acuminate, shorter than the scape; raceme open, 3—8 inches long, becoming longer in fruit; flowers few to many; pedicels slender, 6—10 lines long, about the length of the long-acuminate bracts and the perianth-segments; perianth-segments narrowly oblong, 3—5-nerved, blue or whitish; stamens included; capsule about 4 lines high, somewhat thicker, the valves transversely veined.

This species prefers moist soil in grassy places or in open woods near streams. The flowers appear in April and May. The range is given as from Pennsylvania to Minnesota, south to Georgia, Alabama and Texas. Type locality supposed to be near St. Louis, Missouri.

Specimens in the writer's herbarium were collected in Muscatine, Jefferson and Decatur counties. The species has been reported from Scott county by Barnes, Reppert and Miller. Apparently in Iowa the species is limited to the southeastern and southern portions. It is rather infrequent but wherever it occurs there may be a considerable colony as was noted in the case of the station in Decatur county where it was collected May 23, 1898.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1890—1891, Vol. 1, part 2, p. 90, 1892.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Fitzpatrick, T. J. The Iowa Naturalist, Vol. 1, No. 1, p. 24, January, 1905.

Anderson, J. P. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 135, 1905.

6. YUCCA L. Sp. Pl. 319. 1753.

Represented in our area by a rather large plant, with a short subterranean caudex, narrow leaves, and large bracted nodding white flowers arranged in a terminal raceme or panicle. Perianth-segments 6, separate or slightly united. Stamens hypogynous, included; filaments thickened above, sometimes papillose; anthers small, versatile. Ovary sessile, 3-celled or imperfectly 6-celled; ovules many; style short, with 3 stigmatic lobes.

1. YUCCA GLAUCA Nutt. Fraser's Catalogue. 1813. Bear-grass.

Yucca angustifolia Pursh. Fl. Am. Sept. 227. 1814.

Leaves basal, linear, 1—3 feet long, 2—5 lines wide, stiff, margins with long thread-like fibers, sharp pointed, expanding at the base; scape 1—3 feet long; flowers campanulate, 2—3 inches broad in a raceme or a little-branched panicle which may be 1—4 feet long; pedicels in fruit about one inch long, thick, erect, bracted; perianth-segments ovate, 1—2 inches long; style and stigmas short; capsule oblong, 1—2 inches long, about one inch thick, 6-sided, constricted in the middle; seeds many, flat, about one-half inch broad. Type locality: "On the banks of the Missouri."

This species occurs in western Iowa and ranges northward to South Dakota, southward to Missouri and Texas, westward to Wyoming and Arizona. The flowers appear in May and June and the fruits develop in July. In Iowa the species is frequent or even common on the bare slopes of the Loess hills bordering the valley of the Missouri river. The writer collected the species in Fremont county, Iowa, in fruit, July 29, 1898. Professor Pammel reported the species from Pottawattamie, Harrison, Woodbury and Monona counties.

Arthur, J. C. Contributions to the Flora of Iowa, pp. 32, 43, 1876.

Burgess, R. Bulletin of the Torrey Botanical Club, Vol. 6, Nos. 19 and 20, p. 102, July and August, 1876.

Hitchcock, A. S. Botanical Gazette, Vol. 14, No. 5, p. 128, May, 1889.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, pp. 133—134, 1896; Vol. 9, 1901, pp. 166, 177, 1902.

Britton, N. L. and Brown, A. The Illustrated Flora, Vol. 1, p. 427, 1896.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1898, Vol. 6, p. 198, 1899.

Britton, N. L. Manual, p. 269, 1901.

4. CONVALLARIACEAE Link. Handb. 1: 184. 1829.

LILY-OF-THE-VALLEY FAMILY.

Scapose or leafy-stemmed herbs, without bulbs or corms, usually with broad, alternate, verticillate or basal, parallelled-veined leaves, and solitary, racemose, panicled or umbelloid, regular and perfect flowers. Perianth of 4—6 separate segments or else oblong, cylindric, or urn-shaped and 6-lobed or 6-toothed. Stamens 6, hypogynous or borne on the perianth; anthers variously dehiscent. Ovary 2—3-celled, superior; stigma usually 3-lobed. Fruit a fleshy berry. Seeds few or many.

Leaves reduced to scales; leaf-like branchlets filiform. 1. *Asparagus.*
Leaves alternate, broad; stems simple or moderately branched.
  Perianth-segments separate.
    Perianth-segments 6. 2. *Vagnera.*
    Perianth-segments 4. 3. *Unifolium.*
  Perianth cylindric or oblong, 6-toothed. 4. *Polygonatum.*
Leaves 3, in a whorl below the solitary flower. 5. *Trillium.*

1. ASPARAGUS L. Sp. Pl. 313. 1753.

Herbs having in their early stages simple fleshy scaly stems, becoming later much branched; the branchlets filiform and usually clustered in the axils of the leaves, or else flattened and linear, lanceolate or ovate. Flowers small, solitary, unbelled or racemed; the perianth-segments similar, separate, or somewhat united below, the stamens inserted at their bases; filaments filiform; anthers ovate or oblong, introrse. Ovary sessile, 3-celled, with 2 ovules in each cell; style slender, short; stigmas 3, short, recurved. Berry globose. Seeds few, rounded. This genus contains about one hundred species, natives of the Old World, represented in our flora by the following species:

1. ASPARAGUS OFFICINALIS L. Sp. Pl. 313. 1753. Asparagus.

Plants from a much branched rootstock; the young stems succulent, edible, stout, later becoming branched and 3—7 feet high; the branchlets filiform, 3—9 lines long, less than one-fourth line thick, mostly clustered in the axis of diminutive scales; flowers green, mostly solitary at the nodes, dropping, on filiform peduncles which are 4—5 lines long and jointed near the middle; perianth campanulate, 2—3 lines long; the segments linear, obtuse; stamens included; berry red, about 4 lines in diameter. The type locality is given as: "*Habitat in* Europæ *arenosis.*"

This species has become frequent or even common in waste places, borders or along roadways. The flowers usually appear in May and June and the berries are ripe in July although flowering specimens are to be found in September, the ripened fruit soon following.

In Iowa the species is widely distributed, becoming a weed in some localities. The writer has collected the species in Muscatine, Johnson, Decatur, Shelby, Osceola and Lyon counties, and has observed it in Winneshiek, Linn, Van Buren, Lucas, Page, Fremont, Montgomery, Benton and Emmet counties. Professor Fink reported the species from Fayette county; Professor Hitchcock from Story county; Mr. Gow from Adair county; Barnes, Reppert and Miller from Scott county; and Peck from Hardin county. The species also occurs in Henry and Polk counties.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893.

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Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

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Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 215, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. VAGNERA Adans. Fam. Pl. 2: 496. 1763.

Herbs, with simple leafy stems, scaly below, from rather heavy rootstocks, with ovate, lanceolate or oblong leaves, and small white or greenish flowers in a terminal raceme or panicle. Perianth-segments 6, equal, spreading, with the six stamens inserted at their bases. Ovary sub-globose, sessile, 3-celled, with two ovules in each cell; style short or slender; stigma 3-lobed or 3-grooved. Berry globular, usually with one or two subglobose seeds.

Flowers many, panicled. 1. *V. racemosa.*
Flowers few to several, racemose. 2. *V. stellata.*

1. VAGNERA RACEMOSA (L.) Morong. Wild Spikenard.

Convallaria racemosa L. Sp. Pl. 315. 1753.
Smilacina racemosa Desf. Ann. Mus. Paris, 9: 51. 1807.
Vagnera racemosa Morong, Mem. Torr. Club, 5: 114. 1894.

Rootstock horizontal, thick, fleshy, with many rootlets; stem 1—3 feet high, erect or ascending, leafy, sometimes zigzag, somewhat angled, finely pubescent especially above, frequently glabrous; leaves oval or oblong-lanceolate, sessile or the lower 1—3 inches long, acuminate, finely pubescent beneath and occasionally above, minutely ciliate on the margins; flowers 1—4 lines long, many, in a dense peduncled panicle, about 2 lines broad, equaling the pedicels or longer; perianth-segments oblong; berry red, 2—3 lines in diameter, speckled with purple, aromatic.

This species has a wide range as it occurs from Nova Scotia to British Columbia, south to Georgia, South Carolina, Alabama, Mississippi, Missouri and Arizona.

It occurs in rich woods and thickets, the flowers opening in May and June or occasionally even in July while the ripened fruit may be found in July or early August. The type locality is given as: "*Habitat in* Virginia, Canada."

In Iowa the species is frequent or even common in favored localities. Specimens in the writer's herbarium are from Winneshiek, Muscatine, Johnson, Jefferson, Appanoose, Decatur, Shelby and Emmet counties. The species has been observed growing in Allamakee, Clayton, Dubuque, Union and Des Moines counties. The State University herbarium has specimens from Henry, Lee, Story, Jones, Winnebago, Cerro Gordo and Pottawattamie counties. Professor Fink reported the species from Fayette county; Barnes, Reppert and Miller from Scott county; Gow from Adair county; and Peck from Hardin county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

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Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

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Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

2. VAGNERA STELLATA (L.) Morong. Star-flowered Solomon's Seal.

Convallaria stellata L. Sp. Pl. 316. 1753.
Smilacina stellata Desf. Ann. Mus. Paris, 9: 52. 1807.
Vagnera stellata Morong, Mem. Torr. Club, 5: 114. 1894.

Rootstock horizontal, fleshy, with many rootlets; stem glabrous, 5—20 inches high, leafy, sometimes slightly zigzag; leaves lanceolate or oblong-lanceolate, sessile or somewhat clasping, 2—5 inches long, 6—18 lines wide, acute, acuminate or even bluntish at the apex; raceme 1—2 inches long, sessile or short-peduncled; pedicels 1—4 lines long; flowers usually longer than the pedicels; perianth-segments oblong, obtuse; stamens included; style about as long as the ovary; berry 3—5 lines in diameter, black, or else green with six black stripes.

This species, like the preceding, has a wide range, as it is found from Newfoundland to British Columbia, south to New Jersey, Virginia, Kentucky, Kansas, Wyoming and California. It is also credited to northern Europe. The habitat is moist rich soil in open places. The flowers bloom in May and June and the berries ripen in June and July. Type locality: "*Habitat in* Canada."

In Iowa the species is more or less frequent and fairly distributed. Specimens at hand are from Winneshiek, Johnson, Emmet and Lyon counties. The species was observed in Henry and Des Moines counties. The State University herbarium has specimens from Story, Calhoun, Pottawattamie and Winnebago counties. Professor Pammel reported the species from Woodbury county; Professor Fink from Fayette county; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

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Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; Vol. 3, 1895, p. 134, 1896; Vol. 9, 1901, p. 173, 1902.

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Shimek, B. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 31, 1898; Iowa Geological Survey, Vol. 10, p. 177, 1900.

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Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 203, 1905.

3. UNIFOLIUM Adans. Fam. Pl. 2: 54. 1763.

Low herbs, with slender rootstocks, erect simple stems, a few petioled or sessile leaves, and small white 4-parted flowers arranged in a terminal raceme. Stamens 4, inserted at the bases of the 4 perianth-segments; filaments filiform; anthers introrse. Ovary sessile, globose, 2-celled, with two ovules in each cell; style 2-lobed or 2-cleft, of about the length of the ovary. Berry globular, 1—2-seeded.

1. UNIFOLIUM CANADENSE (Desf.) Greent. Two-leaved Solomon's Seal.

Maianthemum canadense Desf. Ann. Mus. Paris 9: 54. 1807.
Smilacina bifolia var. *canadensis* A. Gray, Man. Ed. 2, 467. 1856.
Unifolium canadense Greene, Bull. Torr. Club, 15: 287. 1888.

Plants 2—8 inches high, glabrous or pubescent, from slender running rootstocks; stems often zigzag; leaves usually 2, ovate or ovate-lanceolate, acute, acuminate or bluntish and cuspidate at the apex, cordate at the base, the sinus being narrow and closed, sessile or short-petioled or occasionally with a petiole one-half inch long, sometimes with a single leaf arising from the rootstock with a petiole as much as four inches long; raceme rather dense, many-flowered, 1—2 inches long; pedicels usually longer than the flowers; perianth-segments oblong, about one line long, obtuse, at length reflexed; stamens usually included; berry reddish, speckled, about two lines in diameter.

This rather delicately formed plant is met with in moist woods from Newfoundland to North Carolina westward to Iowa, South Dakota, and the Northwest Territory. The flowers bloom in May and June and the fruit ripens within a short period.

The Iowa specimens in the writer's herbarium are from Winneshiek, Fayette and Johnson counties. Professor Hitchcock reported the species from Story county; Barnes, Reppert and Miller from Muscatine county; and Peck from Hardin county. In Iowa the species may be said to be infrequent or perhaps rare and apparently limited to the eastern half of the state.

Arthur, J. C. Contribution to the Flora of Iowa, p. 32, 1876.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

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Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Britton, N. L. Manual, p. 272, 1901.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, ol. 12, p. 204, 1905.

4. POLYGONATUM Adans. Fam. Pl. 2: 54. 1763.

Glabrous or pubescent herbs, with thick, jointed and scarred horizontal rootstocks, simple erect or arching stems, scaly below, ovate or lanceolate leaves, and greenish or pinkish axillary, drooping, peduncled flowers. Perianth tubular or oblong-cylindric, 6-lobed. Stamens 6, included; filaments adnate to the perianth for at least half their length; anthers sagittate, introse. Ovary 3-celled, with 2—6 ovules in each cell; style slender; stigma small, capitate or slightly 3-lobed. Berry globular, pulpy, dark blue or blackish, with a bloom.

Whole plant glabrous; filaments smooth, flattish. 1. *P. commutatum.*
Leaves pubescent beneath; filaments filiform, roughened. 2. *P. florum.*

1. POLYGONATUM COMMUTATUM (R. & S.) Dietr. Smooth Solomon's Seal.

Convallaria commutata R. & S. Syst. 7: 1671. 1830.
Polygonatum commutatum Dietr.; Otto & Dietr. Gartenz. 3: 223. 1835.
Polygonatum giganteum Dietr.; Otto & Dietr. Gartenz. 3: 222. 1835.

Whole plant glabrous; stem 1—8 feet high, slender or stout; leaves varying from oval to ovate or lanceolate, the apex acute, acuminate, or blunt, 1—6 inches long, 1—4 inches wide, base narrow, rounded, and somewhat clasping, with a transverse joint-like thickening; lower surface of the leaves lighter green than the upper; peduncles 1—8-flowered, three inches or less in length; pedicels 2—8 lines long, jointed near the base of the flower; perianth greenish, tubular, 6—10 lines long, the six lobes erect; filaments flattish, smooth, adnate; berry 4—6 lines in diameter. Type locality: "Ad specimen in Herb. Cli Martius a Do. Schweinitz in Pennsylvania lectum."

This more or less variable species occurs from Rhode Island to Ontario and Manitoba, south to Georgia, Alabama, Louisiana, Utah and New Mexico. In Iowa the species is frequent in moist woods throughout the state. The flowers appear in May, June and July.

Specimens at hand are from Winneshiek, Johnson, Appanoose, Decatur, Ringgold, Pottawattamie, Shelby, Emmet and Lyon counties. The writer has observed the species growing in Clayton, Dubuque and Page counties. The State University herbarium contains specimens from Lee, Henry and Winnebago counties. Professor Pammel reported the species from Woodbury and Hamilton counties; Professor Bessey from Story county; Professor Fink from Fayette county; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

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Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1895, Vol. 3, p. 134, 1896.

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Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 261, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905

2. POLYGONATUM BIFLORUM (Walt.) Ell. Hairy Solomon's Seal.

Convallaria biflora Walt. Fl. Car. 122. 1788.
Polygonatum biflorum Ell. Bot. S. C. & Ga. 1: 393. 1817.

This species is a lower plant than the preceding. It differs mainly in having the leaves pubescent especially on the veins and pale beneath, the peduncles 1—4-flowered, but frequently 2-flowered and the filiform filaments papillose roughened; berry 3—4 lines in diameter. The type locality is given as South Carolina.

Britton and Brown give the range of this species as: "Woods and thickets, New Brunswick to Ontario and Michigan, south to Florida and West Virginia." The time of blooming is given as April—July. Doubtless Iowa is outside of the range of a species, yet it has been reported a number of times. Professor Fink reports that he collected a single plant along a wooded hillside in Fayette county. Nagel and Haupt reported the species from Scott county; Gow from Adair county; and Peck from Hardin county.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

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Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

5. TRILLIUM L. Sp. Pl. 339. 1753.

Perennial herbs, with erect glabrous simple stems, the three leaves whorled at the summit, and solitary sessile or peduncled bractless flowers. Sepals 3, green, persistent. Petals 3, white, green, pink, or purple, withering or deciduous. Stamens 6, hypogynous; filaments short; anthers linear, mostly introrse. Ovary sessile, 3—6-angled or lobed, 3-celled; ovules usually many in each cell; styles 3, stigmatic along the inner side; berry ovoid or globose, many-seeded.

Flowers sessile.
- Leaves petioled; sepals reflexed. 1. *T. recurvatum.*
- Leaves sessile; sepals not reflexed. 2. *T. sessile.*

Flowers peduncled.
- Leaves ovate to broadly oval, obtuse, 1—2 inches long. 3. *T. nivale.*
- Leaves broadly ovate, acuminate, 2—7 inches long.
  - Petals obovate or oblanceolate. 4. *T. grandiflorum.*
  - Petals ovate or lanceolate.
    - Peduncle about 2 or 3 inches long, erect or declined; petals spreading. 5. *T. erectum.*
    - Peduncle about one inch long or less, recurved; petals recurved. 6. *T. cernuum.*

1. TRILLIUM RECURVATUM Beck, Am. Journ. Science, 11: 178. 1826. Prairie Wake-robin.

Stem solitary, 6—18 inches high, from an oblong thickened rootstock; leaves oval, oblong or ovate, acute, 2—4 inches long, sometimes blotched, narrowed into petioles which are one inch or less in length; flowers sessile, erect; sepals lanceolate, acuminate, one-half to more than one inch in length, reflexed between the peticles; petals oblong-ovate or spatulate, nearly erect, dark purple, clawed, acute or acuminate, equaling or exceeding the sepals; anthers nearly or quite one-half inch in length, much longer than the filaments, connective longer than the sacs; berry ovoid, less than one inch in length, 6-winged above.

This species ranges from Ohio to Minnesota, south to Mississippi and Arkansas. Its habitat is rich woods and thickets. The flowers appear as early as April and remain as late as June and fruiting specimens may be found even in July. Type locality: "HAB. Shady banks of streams. St. Louis. May."

Iowa specimens at hand are from Johnson, Muscatine, Jefferson and Van Buren counties. The writer has seen specimens collected in Scott and Des Moines counties. The State University herbarium has specimens from Johnson, Henry and Louisa counties. The species in Iowa seems to be restricted to the southeast quarter of the state and is generally infrequent. In some restricted localities in Jefferson county the species is quite common.

Flores. Iowa Farmer and Horticulturist. Vol. 1. No. 2, p. 30. June, 1853.
Bessey, C. E. Fourth Biennial Report of the State Agricultural College, p. 122, 1872.
Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.
Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.
Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 2, p. 135, 1877.
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Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898.
Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 262, 1900.

2. TRILLIUM SESSILE L. Sp. Pl. 340. 1753. Sessile-flowered Wake-robin.

This species is readily distinguished from *Trillium recurvatum* Beck, by having sessile leaves and the sepals not being reflexed. The habitat is moist woods and thickets and the flowers come in April and May. The range is given as from Pennsylvania to Ohio and Minnesota, south to Florida, Alabama, Mississippi and Arkansas, thus placing Iowa in the probable range of the species. Professor Bessey reported the species from Burlington, Des Moines county, in 1872, but the find appears not to have been confirmed since. The type locality is: "*Habitat in* Virginia, Carolina."

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.
Flores. Iowa Farmer and Horticulturist, Vol. 1, No. 2, p. 30, June, 1853.
Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.
Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

3. TRILLIUM NIVALE Riddell. Syn. Fl. W. States, 93. 1835. Early Wake-robin.

Stem 2—6 inches high, from a short thick rootstock; leaves ovate to broadly oval, 1—2 inches long, apex obtuse, base narrow or rounded, petioles 2—6 lines long; flowers erect, bent, or recurved beneath the leaves, peduncles one inch or less in length; sepals narrowly oblong or oblong-lanceolate, obtuse, 6—12 lines long; petals white, oval or oblong,

obtuse, exceeding the sepals, erect-spreading; filaments and anthers of about equal length, the connective not prolonged; styles slender; berry globose, 3-lobed, about one-half inch in diameter.

This species ranges from Pennsylvania to Ohio and Kentucky, west to Minnesota and Iowa. The flowers appear as early as March and as late as May. The habitat is woods and thickets. In Iowa the species is frequent in favored localities and is found in most portions of the state.

Specimens in the writer's herbarium are from Winneshiek, Johnson and Decatur counties The State University herbarium has specimens from the additional counties of Linn, Henry and Chickasaw counties. Professor Fink reported the species from Fayette county; Professor Pammel from Cherokee county; Professor Hitchcock from Boone county; Upham from Emmet county; Gow from Adair county; Professor Bessey from Des Moines county; and Peck from Hardin county.

Flores. Iowa Farmer and Horticulturist, Vol. 1, No. 2, p. 30, June, 1853.

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Britton, N. L. and Brown, A. Illustrated Flora, Vol. 1, p. 436, 1896.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 104, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 130, 1898.

Fitzpatrick T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898; Vol. 6, 1898, p. 198, 1899.

Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

4. Trillium grandiflorum (Michx.) Salisb. Large-flowered Wake-robin.

Trillium rhomboideum var. *grandiflorum* Michx. Fl. Bor. Am. 1: 216. 1803.
Trillium grandiflorum Salisb. Par. Lond. 1: pl. 1. 1805.

This species much resembles *Trillium erectum* L., but differs obviously in having the petals usually much longer and obovate or oblanceolate in outline. The species occurs in woods from Quebec to Ontario and Minnesota; south to Florida and Missouri. The flowers appear in May or June. Professor Bessey reported the species from Fayette, Fayette county, and Burlington, Des Moines county, but his reports lack confirmation.

Bessey, C. E. Fourth Biennial Report of the Iowa Agricultural College, p. 122, 1872

5. TRILLIUM ERECTUM L. Sp. Pl. 340. 1753. Ill-scented Wake-robin.

Trillium pendulum Willd. Neue Schrift, 3: 421. 1801.
Trillium rhomboideum Michx. Fl. Bor. Am. 1: 215. 1803.

Stem stout, 8—20 inches high, solitary or frequently two, from an oblong thickened rootstock, rootlets many, long, thick; leaves broadly rhombic-ovate, 3—7 inches long and as wide, sessile, narrowed at the base, acuminate; peduncle one and one-fourth to three or four inches long, erect, inclined or declined beneath the leaves; sepals lanceolate, acuminate, spreading, one-half to one and one-half inches long; petals ovate to lanceolate, acute or acutish, spreading or somewhat recurved, equaling or exceeding the petals, usually white or greenish, sometimes pinkish or dark purple; filaments short, anthers twice as long; styles short, spreading or recurved; berry ovoid, somewhat 6-lobed, reddish, one inch or less in length.

This plant may be found in rich woods throughout the state. The flowers appear mostly in May but are to be seen during the last of April and even the first week or two of June. The species has been frequent, but is becoming scarcer and more local, in many cases only a few plants are to be found in one locality. The flowers are odorous but not necessarily disagreeable. The species ranges from Nova Scotia west to Manitoba, south to North Carolina, Georgia, Alabama, Tennessee and Missouri. Type locality: "*Habitat in Virginia.*"

In Iowa the writer has secured specimens from Winneshiek, Fayette, Jones, Muscatine, Johnson, Shelby, Crawford, and Emmet counties. The State University herbarium has specimens from the additional counties of Delaware and Calhoun. Professor Hitchcock reported the species from Story county; Barnes, Reppert and Miller from Scott county; and Peck from Hardin county; also Professor Bessey reported the species as variety *album* from Poweshiek county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876; Proceedings of the Davenport Academy of Natural Sciences, Vol. 2, p. 126, 1877.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Rigg, G. B. Notes on the Flora of Calhoun County, Iowa, p. 27, 1896.

Shimek, B. Bulletin from the Laboratories of Natural History of the State University of Iowa, Vol. 3, No. 4, p. 212, February, 1896.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 130, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 166, 1898.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 262, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

6. TRILLIUM CERNUUM L. Sp. Pl. 339. 1753. Nodding Wake-robin.

Stem 8—20 inches; leaves rhombic-ovate, apex acuminate, base narrowed, sessile or nearly so; peduncle one-half to slightly more than an inch in length, recurved beneath the leaves; the flower drooping; sepals lanceolate or ovate-lanceolate, acuminate, 6—12 lines long; petals white or pink, ovate-lanceolate to oblong-lanceolate, recurved, wavy-margined, equaling or exceeding the sepals; filaments and anthers of about equal length; style stout, recurved; berry ovoid, red-purple, pendulous, 8—10 lines long.

The range of this species is given as from Nova Scotia to Ontario and Minnesota, south to Georgia, Alabama and Missouri. This places Iowa within the range. The flowers appear in April, May or June, and the habitat is rich woods. There is a striking resemblance between this species and *Trillium erectum* L., in fact the differences in many cases as shown by specimens being very slight. The type locality is: "*Habitat in* Carolina."

The only Iowa specimen in the writer's herbarium is from Winneshiek county. Professor Fink reported the species as infrequent in low woods in Fayette county, which locality is also given by Professor Bessey, and Professor Hitchcock credits the species to Story county.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

5. SMILACEAE Vent. Tabl. 2: 146. 1799.

SMILAX FAMILY.

A family of plants consisting mostly of vines having woody or herbaceous, often prickly stems, alternate, nerved, netted-veined, petioled, punctate or lineolate leaves, and small, usually greenish flowers disposed in axillary umbels. Perianth-segments 6. Stamens usually 6, distinct; filaments ligulate; anthers basi-fixed, 2-celled, introrse. Ovary 3-celled; ovules 1 or 2 in each cell; style short or none; stigmas 1—3. Fruit a globose berry with 1—6 seeds. Represented in our flora by the genus Smilax.

1. SMILAX L. Sp. Pl. 1028. 1753.

Plants usually with large tuberous rootstocks, twining stems which climb by means of tendril-like appendages which are spirally coiling and are borne from the base of the sheathing persistent petiole after the manner of stipules. The lower leaves are mere scales, the upper are entire or lobed, deciduous. Flowers regular, in ours dioecious. Pedicels from a pitted globose or conic receptacle, usually among minute bractlets. Ovary wanting in the staminate flowers. Pistillate flowers usually smaller and with 1—6 abortive stamens. Berries black or purple in our species and ripening during the first year.

Stem annual, herbaceous, unarmed.
  Petioles with tendrils; stems climbing. 1. *S. herbacea.*
  Petioles without tendrils; stems erect. 2. *S. ecirrhata.*

Stems perennial, woody, usually armed with prickles.
Leaves lanceolate to round ovate, 5-nerved. 3. *S. rotundifolia.*
Leaves ovate, 7-nerved. 4. *S. hispida.*
Leaves round-ovate, usually narrowed at the middle, 7—9-nerved. 5. *S. pseudochina.*

1. SMILAX HERBACEA L. Sp. Pl. 1030. 1753. Carrion-flower.

Smilax pulverulenta Michx. Fl. Bor. Am. 2: 238. 1803.
Smilax pedunculafis Muhl.; Willd. Sp. Pl. 4: 786. 1806.
Coprosmanthus peduncularis Kunth, Enum. 5: 264. 1850.
Coprosmanthus herbaceus Kunth, Enum. 5: 265. 1850.

Tubers numerous, short and thick, scarred; stem terete or somewhat angled, glabrous, more or less branched; tendrils numerous; leaves ovate or rounded, sometimes lanceolate, the apex acute, acuminate or cuspidate, base obtuse or cordate, thin, sometimes downy beneath, 7—9-nerved, 2—5 inches long, 1—4 inches wide, petioles from one-half inch to four inches long; peduncles 4—9 inches long, flattened; umbels usually many flowered; pedicels 3—10 lines long; flowers ill-scented; stamens 6, sometimes 5 or 7; berries bluish black, 3—4 lines in diameter, 2—4-seeded.

This species is frequent in thickets throughout Iowa. The flowers appear in April, May or June, and the fruit ripens in July or August. The species ranges widely, being found from the Dakotas southward to Nebraska and Louisiana, eastward to Florida and New Brunswick. Linnaeus gave the type locality as: "*Habitat in* Virginia, Marilandia."

Specimens in the writer's herbarium are from Winneshiek, Dubuque, Johnson, Jefferson, Appanoose, Decatur, Union, Shelby and Lyon counties. The species was seen growing in Allamakee county. Specimens in the State University herbarium are from the additional counties of Hancock, Emmet, Floyd and Jones. Professor Pammel reported the species from Woodbury county; Barnes, Reppert, and Miller from Scott and Muscatine counties; Professor Bessey from Story and Poweshiek counties, and Peck from Hardin county. Forms occur having no tendrils and some forms have the stems glaucous and the under surfaces of the leaves puberulent.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.
Arthur, J. C. Contributions to the Flora of Iowa, p. 32, 1876.
Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.
Upham, Warren. Catalogue of the Flora of Minnesota, p. 143, 1884.
Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.
Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; 1895, Vol. 3, p. 133, 1896; 1901, Vol. 9, p. 173, 1902.
Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.
Shimek, B. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 31, 1898; Iowa Geological Survey, Vol. 10, p. 176, 1900.
Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.
Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898; 1898, Vol. 6, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

2. SMILAX ECIRRHATA (Engelm.) S. Wats.

Smilax herbacea Ell. Sk. 2: 702. 1824.
Coprosmanthus herbaceus var. *ecirratus* Engelm.: Kunth, Enum. 5: 266. 1850.
Smilax herbaceae var. *ecirrhata* Gray: DC. Monogr. Phan. 1: 52. 1878.
Smilax ecirrhatus S. Watson in A. Gray, Man. Ed. 6, 520. 1890.

Main root rather heavy, branched; rootlets usually many, long and slender; stem herbaceous, glabrous, simple, erect, 6—30 inches high; tendrils rarely present near the summit; leaves ovate, thin, 5—9-nerved, more or less whitish pubescent beneath, 2—6 inches long, 1—4 inches wide, apex acute, acuminate, cuspidate, or obtuse, base cordate or rounded, margin entire or erose-denticulate; petioles 1—3 inches long; leaves frequently verticillate at the summit of the stem; peduncles 1—4, 2—3 inches in length; pedicels 2—6 lines long; flowers ordinarily 6—20, in an umbel; filaments equaling the anthers or longer. Type locality not definitely given.

Britton and Brown give the range of this species as from Virginia to Minnesota and Florida. The flowers appear in May and June. The habitat is along fence-ways and in thickets or open places. Iowa specimens at hand are from Winneshiek, Fayette, Johnson, Emmet and Lyon counties. The State University herbarium has specimens from the additional counties of Henry, Winnebago, Calhoun, Delaware and Muscatine counties. Barnes, Reppert and Miller reported the species from Scott county and Peck from Hardin county.

Shimek, B. Bulletin from the Laboratories of Natural History of the State University of Iowa, Vol. 3, No. 4, p. 199, February, 1896.

Rigg, G. B. Notes on the Flora of Calhoun County, Iowa, p. 26, 1896.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

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Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898.

Barnes, W. D.: Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.

Anderson, J. P. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 135, 1905.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

3. SMILAX ROTUNDIFOLIA L. Sp. Pl. 1030. 1753. Greenbrier.

Smilax caduca L. Sp. Pl. 1030. 1753.
Smilax quadrangularis Willd. Sp. Pl. 4: 775. 1806.

Rootstock long, somewhat tuberous; stem woody, terete, the branches and young shoots often 4-angled, glabrous, armed with scattering straight or little curved prickles, sometimes none; petioles 3—6 lines long; leaves thin when young, becoming thick and shiny when mature, ovate to nearly orbicular, or lanceolate, acute or acuminate at the apex,

margins entire or erose-denticulate, rounded or cordate at the base; 2—6 inches long, 1—3 inches wide, 5-nerved, the outer pair of nerves usually weaker; peduncles flattened, 3—12 lines long; umbels 6—25-flowered; pedicels 1—4 lines long; filaments longer than the anthers; berries black, 2—3 lines in diameter, 1—3-seeded. Type locality: "*Habitat in* Canada."

This species is with us rather infrequent, occurring in woods and thickets, and blooms from April until June. The range is said to extend from Ontario to Minnesota, south to Florida, Georgia, Alabama, Texas and Colorado. The Iowa specimens in the writer's herbarium were collected in Decatur and Fremont counties. The species was reported from Dubuque county by Professor Macbride.

Macbride, Thomas H. Iowa Geological Survey,' Vol. 10, p. 65, 1900.

4. SMILAX HISPIDA Muhl.; Torr. Fl. N. Y. 2: 302. 1843.

Stem usually thickly beset with slender straight prickles, terete below, branches more or less angled; petioles 4—10 lines long, bearing tendrils; leaves ovate, thin, green on both sides, entire or denticulate, 7-nerved, the outer pair of nerves less prominent, occasionally a faint additional pair near the margin, 2—5 inches long, 1—4 inches wide, apex acute or cuspidate, base obtuse or subcordate; peduncles 1—2 inches long, flattened; umbels 10—30-flowered; pedicels slender, 2—6 lines long; berries 2—3 lines in diameter, bluish black. In speaking of the type locality, Doctor Torrey says: "Oneida county (*Dr. Knieskern*), and probably elsewhere in the western part of the State [New York]. *Fl.* June. The fertile flowers are described from Michigan specimens."

This species occurs in open woods and thickets from Ontario to Minnesota and Nebraska, south to Texas and Virginia. It blooms from May until July and the fruit may be gathered from July until October. In Iowa the species is frequent and widely distributed.

Specimens in the writer's herbarium are from Fayette, Dubuque, Johnson, Decatur, Ringgold and Shelby counties. The species was observed in Allamakee, Clayton, Adams and Fremont counties. The State University herbarium has specimens from the additional counties of Winnebago, Cerro Gordo, Emmet, Lee, Delaware, and Pottawattamie counties. Professor Bessey reported the species from Story county; Professor Pammel from Boone county; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

Bessey, C. E. Fourth Biennial Report of the Iowa Agricultural Colege, p. 122, 1872.

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Upham, Warren. Catalogue of the Flora of Minnesota, p. 143, 1884.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 520, 1892.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

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Cameron, John E. Iowa Geological Survey, Vol. 8, p. 199, 1898.
Barnes, W. D.; Reppert, Fred; Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.
Macbride, Thomas H. Iowa Geological Survey, Vol. 10, p. 650, 1900; Forestry Notes for Iowa, Dubuque County, p. 29, 1900.
Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 203, 1901; Vol. 11, 1903, p. 278, 1904.
Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.
Shimek, B. Report of the Iowa State Horticultural Society, 1903, Vol. 38, p. 461, 1904.
Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

5. SMILAX PSEUDOCHINA L. Sp. Pl. 1031. 1753.

Whole plant glabrous, rootstock usually with large tubers; stem terete, the lower portion covered with straight needle-shaped prickles, the upper portion and the angled branches unarmed; leaves firm, becoming leathery, green on both sides or glaucous beneath, ovate, often narrowed at the middle or lobed below, 7—9-nerved, 2—5 inches long, 1—3 wide, margins sometimes denticulate, apex acute or cuspidate, base rounded or cordate; peduncles flattened, 1—3 inches long; umbels 12—40-flowered; pedicels 3—4 lines long; stamens 6—10; berries black, 8—16, 2—3 lines in diameter, 1—3-seeded. The type locality is: "*Habitat in* Virginia, Jamaica."

This species is said to occur in dry soil in thickets from Marland to Nebraska, south to Florida, Alabama and Texas, blooming from March until August. The known Iowa localities are Delaware and Cerro Gordo counties, reported by Professor Shimek.

Shimek, B. Report of the Iowa State Horticultural Society, 1903, Vol. 38, p. 461, 1904; Notes on Some Iowa Plants, p. 1, 1904.

6. AMARYLLIDACEAE Lindl. Nat. Syst. Ed. 2: 328. 1836.

AMARYLLIS FAMILY.

Perennial herbs, with bulbs or rootstocks, leafy or scapose stems, usually narrow entire leaves, and perfect, more or less regular, flowers. Perianth 6-lobed or 6-parted, distinct or united below into a tube which is adnate to the ovary. Stamens 6, inserted at the base of the perianth-segments or in the throat of the perianth opposite the lobes. Anthers versatile or basifixed, 2-celled, longitudinally dehiscent. Ovary wholly or partly inferior, 3-celled. Style slender, entire, lobed, or divided into 3 stigmas. Ovules 1 to many. Fruit a capsule, rarely fleshy. Seeds black. Represented in our flora by the genus *Hypoxis*.

1. HYPOXIS L. Syst. Ed. 10, 2: 986. 1759.

Low, usually villous herbs, with a grass-like aspect, from corms or rootstocks, having narrow leaves, and a few comparatively small flowers on slender scapes. Perianth 6-parted to the summit of the ovary, the segments equal or subequal, withering-persistent, the outer ones greenish below, the stamens inserted at their bases. Anthers erect. Ovary 3-celled; style short; stigmas 3, erect; ovules many, arranged in two rows in each cell.

1. Hypoxis hirsuta (L.) Coville. Star-grass.

Ornithogalum hirsutum L. Sp. Pl. 306. 1753.
Hypoxis erecta L. Syst. Ed. 10, 2: 986. 1759.
Hypoxis hirsuta Coville, Mem. Torr. Club, 5: 118. 1894.

Corm globose to ovoid or oblong, 3—6 lines in diameter; roots many, fibrous; leaves basal, villous or glabrate, narrowly linear, 1—3 lines wide; scapes 2—6 inches high, usually shorter than the leaves, villous above, generally glabrous below, slender, erect; flowers umbellate, 1—6; pedicels longer than the subulate bracts; perianth-segments narrowly oblong, obtuse or acutish, spreading, 3—5 lines long, bright yellow within, greenish and villous without; stamens slightly unequal; style 3-angled, somewhat shorter than the stamens, the stigmas decurrent on the angles; capsule 1—2 lines in diameter; seeds globular, black, angled, short-beaked by the stalks.

The range of this species is quite extensive, it being from Maine to Assiniboia, south to Florida, Alabama, Arkansas, Texas and Kansas. In Iowa it is common in low prairie soil, though frequent in higher and drier situations. It is also found in meadows and open woods. The flowers commonly appear in May and June, and it is stated even so late as October. The type locality is: "*Habitat in* Virginia, Canada."

In Iowa the species is widely distributed. Specimens in the writer's herbarium are from Winneshiek, Johnson, Decatur, and Shelby counties. Specimens in the State University herbarium are from the additional counties of Emmet, Delaware, Henry, Lee, Calhoun and Lyon. Professor Bessey reported the species from Story, Poweshiek, Des Moines and Warren counties; Barnes, Reppert and Miller from Scott and Muscatine counties; Gow from Adair county; and Peck from Hardin county.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.
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Shimek, B. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 31, 1898; Iowa Geological Survey, Vol. 10, p. 177, 1900.
Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.
Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898.
Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.
Gow, James E. Proceedings of the Iowa Academy of Sciences, 1900, Vol. 8, p. 159, 1901.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 277, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

7. DIOSCORIACEAE Lindl. Nat. Syst. Ed. 2, 359. 1836.

YAM FAMILY.

This family is represented in the Iowa flora by the following genus and species:

1. DIOSCOREA L. Sp. Pl. 1032. 1753.

1. DIOSCOREA VILLOSA L. Sp. Pl. 1033. 1753. Wild Yam-root.

A twining vine, from a knotted horizontal woody rootstock, which is an inch or less in diameter. Stem 4—12 feet long, glabrous; leaves thin, ovate, entire, alternate, or the lower ones opposite or verticillate in fours, 2—6 inches long, 1—4 inches wide, 9—13-nerved, green and glabrous above, pale and frequently minutely pubescent beneath, apex acuminate, base cordate; petioles slender, 2—7 inches long; flowers greenish yellow, on very short pedicels, the staminate about one line broad and in drooping panicles which are 3—6 inches long, the pistillate about 3 lines long and in drooping spicate recemes; perianth 6-parted, greenish, adherent in the fertile plant to the 3-celled ovary; stamens 6, inserted at the bases of the perianth-segments; style 3, distinct; capsule 3-valved, 3-angled, membranous, yellowish green, 7—12 lines long, strongly 3-winged, with one or two flat thin winged seeds in each cavity.

This species ranges from Rhode Island to Ontario and Minnesota, south to Florida and Texas. In Iowa the species seems to be confined to the central, eastern, and southern portions, where it is rather common. The flowers appear in June and July and the fruit ripens in August and September, remaining on the vines until late into the winter season. The habitat is moist soil in thickets and along borders. Type locality: "*Habitat in* Virginia, Florida."

Specimens in the writer's herbarium are from Winneshiek, Dubuque, Johnson, Van Buren, Appanoose, Decatur, Ringgold and Union counties. Professor Bessey reported the species from Story, Floyd and Poweshiek counties; Professor Fink from Fayette county; Barnes, Reppert and Miller from Scott and Muscatine counties; and Peck from Hardin county.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 31, 1876.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 519, 1892.

Fink, Bruce. Proceedings of the Iowa Academy of Sciences, 1896, Vol. 4, p. 103, 1897.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 129, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898; Vol. 6, 1898, p. 198, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 278, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

8. IRIDACEAE Lindl. Nat. Syst. Ed. 2, 382. 1836.

Iris Family.

Perennial herbs, with narrow equitant leaves, and perfect regular or irregular, more or less clustered, bractèate flowers. Perianth 6-lobed or 6-parted, the tube adnate to the ovary. Stamens 3, inserted on the perianth opposite the outer lobes; filaments slender, separate or united; anthers 2-celled, extrorse. Ovary inferior, usually 3-celled; ovules many; style 3-cleft. Capsule 3-celled, 3-angled or 3-lobed, many-seeded, loculicidally dehiscent.

Style-branches opposite the anthers, broad, petaliferous. 1. *Iris*.
Style-branches alternate with the anthers, slender or filiform.
  Filaments all distinct; seeds fleshy. 2. *Gemmingia*.
  Filaments united; seeds dry. 3. *Sisyrinchium*.

1. IRIS L. Sp. Pl. 38. 1753.

Herbs, with horizontal or creeping rootstocks, erect stems, erect or ascending leaves, and large regular terminal flowers. Perianth-segments 6, clawed, united into a tube below. Stamens inserted at the base of the outer perianth-segments; anthers oblong or linear. Ovary 3-celled; style 3-divided, the division petal like and arching over the stamens, the stigmatic surfaces being under the two lobed tips. Capsule oblong or oval, 3—6-angled or lobed. Seeds many, vertically compressed in one or two rows in each cell.

1. Iris versicolor L. Sp. Pl. 39. 1753. Larger Blue Flag.

Rootstock horizontal, thick; roots fibrous; stems nearly or quite terete, 2—3 feet high, straight or flexuous; leaves erect, usually shorter than the stem, more or less glaucous, 1—2 feet long, 6—12 lines wide; bracts usually longer than the pedicels, the lower one frequently leaf-like; flowers one to several, violet-blue, variegated with yellow, green, and white; perianth-segments glabrous, crestless, the outer ones spatulate, 2—3 inches long, the inner ones shorter and narrower; perianth-tube 4—6 lines long, dilated upwards; ovary 10—18 lines long; capsule 1—2 inches long, 8 lines in diameter, faintly 3-lobed; seeds in two rows in each cell, 2—3 lines across.

This species ranges from Newfoundland to Manitoba, south to Florida, Alabama, Louisiana and Arkansas. It blooms from May until July and its habitat is low wet grassy places and in marshes and shallow lakes. In Iowa the species is common and generally distributed. Type locality: "*Habitat in* Virginia, Marilandia, Pensylvia."

Specimens in the writer's herbarium are from Winneshiek, Johnson, Appanoose, Decatur, Union, Ringgold, Emmet and Dickinson counties. The species were observed growing in Allamakee, Page, Palo Alto, Humboldt, Kossuth, Wright, Franklin and Hardin counties. The State University herbarium has specimens from the additional counties of Scott, Lee, Calhoun and Winnebago. Professor Bessey reported the species from Story, Fayette, Floyd and Des Moines counties; Professor Pammel from Woodbury county; and Barnes, Reppert and Miller from Scott and Muscatine counties.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Flores. Iowa Farmer and Horticulturist, Vol. 1, No. 3, p. 47, July, 1853.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 121, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 31, 1876.

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Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 519, 1892.

Pammel, L. H. Proceedings of the Iowa Academy of Sciences, 1892, Vol. 1, part 3, p. 60, 1893; Vol. 3, 1895, p. 133, 1896; Vol. 9, 1901, p. 169, 1902.

Rigg, G. B. Notes on the Flora of Calhoun County, Iowa, p. 26, 1896.

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Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898; Vol. 6, 1898, p. 197, 1899.

Barnes, W. D.; Reppert, Fred; and Miller, A. A. Proceedings of the Davenport Academy of Sciences, Vol. 8, p. 260, 1900.

Cratty, R. I. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 216, 1904.

Mueller, H. A. Proceedings of the Iowa Academy of Sciences, 1903, Vol. 11, p. 277, 1904.

Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, Vol. 12, p. 204, 1905.

2. GEMMINGIA Fabr. Enum. Pl. Hort. Helm. 1759.

A monotypic genus of eastern Asia represented in our flora by its single species as an escape.

1. Gemmingia chinensis (L.) Kuntze. Blackberry Lily.

Ixia chinensis L. Sp. Pl. 36. 1753.
Belamcanda chinensis DC. in Red. Lil. 3: pl. 121. 1807.
Pardanthus chinensis Gawler, in Koenig & Sims, Ann. Bot. 1: 246. 1805.
Gemmingia chinensis Kuntze, Rev. Gen. Pl. 2: 701. 1891.

Rootstock short, thick, producing offshoots; roots fibrous; stem stout 1—4 feet high; leaves pale green, equitant, folded, nearly erect, 8—15 inches long, 8—14 lines wide; bracts lanceolate, 2—6 inches long, the upper scarious; flowers several, in terminal bracted clusters, 1—2 inches across, orange colored, mottled with crimson and purple on the upper side; perianth-segments 6, obtuse, slightly united below, persistent and coiling together; stamens inserted at the base of the segments; filaments distinct; anthers linear-oblong; style slender, enlarged above; style 3,

slender, alternate with the anthers; capsule about one inch in height, six lines in diameter, obovoid, truncate or rounded above, thin-walled, loculicidally 3-valved, the valves recurving and at length falling away and exposing the erect mass of globose black fleshy seeds, resembling a blackberry. Type locality: "*Habitat in* India."

This species blooms in June and July, and is found frequently in cultivation and occasionally as an escape along waysides and in waste places.

The writer collected specimens of this species in Page, Taylor and Ringgold counties and noted its occurrence in Dubuque county. Professor Hitchcock reported it from Story county.

Hitchcock, A. S. Transactions of the Academy of Science of St. Louis, Vol. 5, p. 519, 1892.

Fitzpatrick, T. J. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 128, 1898.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1898, Vol. 6, p. 197, 1899.

3. SISYRINCHIUM L. Sp. Pl. 954. 1753.

Perennial tufted herbs, with slender, simple or branched, 2-edged or 2-winged stems, linear grass-like leaves, and small blue or bluish terminal umbellate flowers from a pair of equal or unequal erect bracts. Perianth-tube short or none; the segments 6, spreading, oblong or obovate, equal, aristulate. Filaments united to above the middle. Ovary 3-celled, each cell with several ovules. Style-branches filiform, alternate with the anthers.

The two bracts of the spathe subequal; stems broadly winged; leaves 1—3 lines wide. 1. *S. graminoides.*

The two bracts of the spathe very unequal; stems scarcely winged; leaves a line or less in width. 2. *S. angustifolium.*

1. SISYRINCHIUM GRAMINOIDES Bicknell, Bull. Torr. Club, 23: 133, pl. 263. 1896.

Sisyrinchium gramineum Curtis, Bot. Mag. t. 464. 1799. Not Lam.
Sisyrinchium anceps S. Watson in A. Gray, Man. Ed. 6, 515. 1890. Not Cavanilles.
Sisyrinchium bermudiana L. var. *anceps* Gray.

Whole plant light green, slightly glaucous; stem 8—16 inches high, stout, erect, broadly 2-winged, sometimes with two unequal branches above which are subtended by a leaf; basal leaves 6—10 inches long, equal to or shorter than the stem, 1—3 lines wide; bracts about one inch long, subequal or the outer one prolonged; umbels 1—4-flowered; pedicels filiform, 8—12 lines long, exceeding the bracts, erect, spreading, or recurved; flowers 5—8 lines across, blue, the outer surface as well as the ovary sparingly pubescent; capsule subglobose, 2—3 lines in diameter; seeds black, nearly globular. Curtis gave the type locality as: "A native of Virginia."

In Iowa this species occurs infrequently in grassy places in open woods and borders. The flowers appear in May and June. The species ranges from New Hampshire and Massachusetts to Minnesota, south to Florida and Texas.

Specimens at hand are from Johnson, Henry and Decatur counties. Professor Bessey reported the species from Story county.

Bessey, C. E. Fourth Biennial Report Iowa State Agricultural College, p. 122, 1872.

Arthur, J. C. Contributions to the Flora of Iowa, p. 31, 1876.

Fitzpatrick, T. J. and M. F. L. Proceedings of the Iowa Academy of Sciences, 1897, Vol. 5, p. 165, 1898.

2. SISYRINCHIUM ANGUSTIFOLIUM Mill. Gard. Dict. Ed. 8. 1768.

Sisyrinchium anceps Cav. 6: 345. pl. 190. f. 2. 1788.
Sisyrinchium mucronatum Michx. Fl. Bor. Am. 2: 33. 1803.
Sisyrinchium bermudiana L. of American authors.

Whole plant pale green, glaucous; stems 4—14 inches high, erect, rigid, usually unbranched, 2-edged, narrowly 2-winged; leaves usually all basal, one line or less in width, rigid, somewhat setaceous, shorter than the stem; bracts unequal, sometimes purplish, the lower one about two inches long, the upper one inch long; umbels 2—4-flowered; flowers 6—8 lines across, violet, blue or white; pedicels erect, 6—8 lines long, shorter than the shortest bract; capsule subglobose, 2—3 lines in diameter, sometimes purple tinged; seeds brown, less than a line long, somewhat obovoid. Type locality not given.

This species ranges from Newfoundland to British Columbia, south to Virginia, Kansas and Colorado. In Iowa the flowers appear from April until August. The habitat is prairie soil, fields and meadows, preferring moist places. In occurrence the species is common.

Iowa specimens in the writer's collection are from Winneshiek, Johnson, Decatur, Osceola, Shelby, Emmet and Dickinson counties. The species was noted in Des Moines and Page counties. Specimens in the State University herbarium are from the additional counties of Muscatine, Henry, Lee, Delaware, Calhoun, Polk, Lyon and Pottawattamie counties. Professor Bessey reported the species from Fayette and Warren counties; Professor Hitchcock from Story county; Gow from Adair county; Peck from Hardin county; and Barnes, Reppert and Miller from Scott and Muscatine counties.

Parry, C. C. Owen's Report of the Geological Survey of Wisconsin, Iowa and Minnesota, p. 619, 1852.

Bessey, C. E. Fourth Biennial Report of the Iowa State Agricultural College, p. 122, 1872.

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Nagel, J. J. and Haupt, J. G. Proceedings of the Davenport Academy of Natural Sciences, Vol. 1, p. 164, 1876.

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Peck, Morton E. Proceedings of the Iowa Academy of Sciences, 1904, p. 204, 1905.

SOME OF THE FLOWERING PLANTS OF CALCASIEU PARISH, LOUISIANA.

BY J. M. LINDLY.

Calcasieu Parish is the largest county in the state of Louisiana. It is about sixty miles east and west, and about fifty miles north and south, and is located in the southwestern part of the state. It adjoins Texas on the west, and is separated from the Gulf of Mexico on the south by only one intervening county. It is bounded on the north by Vernon and Rapids Parishes; on the east by St. Landry, Acadia and Vermilion Parishes; on the south by Cameron Parish; and on the west by the state of Texas. The Sabine river forms its boundary line on the west. Bayou Nezpique and the Mermenteau river from the greater part of its eastern boundary.

The Calcasieu river enters the Parish near the northeast corner and flows southwesterly, receiving several small tributaries from the west. The county is generally timbered except in the southeastern part, which is a natural prairie.

It was my good fortune to spend the winter of 1893-4 in the little town of Welsh in the midst of this prairie region, which is about thirty miles in diameter. Ten years prior thereto, this prairie was practically unoccupied, and served as a range for wandering herds of cattle. About 1886 northern emigration set in and farm houses began to dot the prairie. Land at that time could be bought for twelve and one-half cents an acre, but now sells from twenty-five to fifty dollars per acre. This prairie is now given to diversified farming, the main crop being rice, with cotton, corn and sugar cane as minor paying crops. About two or three years ago petroleum of superior quality and in great abundance was found at Welsh and its neighboring town of Jennings on the east. This latest development of its resources has given this locality more than state-wide prominence. The little vilage of Welsh in 1894 had a population of two or three hundred. Now it claims twelve hundred.

This prairie lies just west of that part of Louisiana that Longfellow immortalized in his poem of "Evangeline".

> "On the banks of the Teche, are the towns of St.
> Maur and St. Martin. * * * *
> Beautiful is the land, with its prairies and
> forests of fruit-trees:
> Under the feet a garden of flowers, and the
> bluest of heavens
> Bending above and resting its dome on the
> Walls of the forest.
> They who dwell there have named it the Eden
> of Louisiana."

Again,

> "Slowly they entered the Teche, where it flows
> through the green Opelousas."

The early settlers in this region were French. Some are supposed to be descendants of the exilede Acadians of eastern Canada during the "French and Indian" war of 1754-'63.

The plants enumerated on the following pages are mostly natives of the South. If belonging to a more northerly latitude, I have mentioned them to show to some extent, the range of their natural distribution; or if cultivated, that of their adaptability.

I have used dates to show that many were in bloom in mid-winter. To one from the cold winters of the North, the sight of blooming flowers in the fields during mid-winter is almost marvelous.

Wood's Botany and Florist of 1871, was found to be the most useful. Gray's Manual of Botany of 1889 contained a description of very few of the plants examined.

I regret that my spare time for botanizing was so limited that there were many species of flowers on the open prairie and of trees in the woods that I could not find time to examine. There was not a day during the entire winter but I could find flowers out doors.

At the end of each description I have added the initials of the Botany used in the final determination of the species, B. B. for Britton and Brown's, G. for Gray's and W. for Wood's.

ACANTHACEAE.

Ruellia strepens L. Smooth Ruellia. Specimen in flower, May 3, 1894, in Oscar Fulton's woods, southwest of Welsh. B. B.

AMARYLLIDACEAE.

Narcissus biflorus. Primrose-peerless. Secured by Miss Belle Singleton, January 19, 1894. W.

Narcissus odorus. Great Jonquil. In full bloom, January 21, 1894, in Oscar Fulton's front yard in Welsh. A cultivated exotic. W.

Pancratium rotatum Gawl. Growing in the low moist ground on the west side of the roadway near the home of Mr. Moore on the road that runs north from Welsh, April 15, 1894, and known in that neighborhood as Spider Lily. W.

APOCYNACEAE.

Nerium odorum. Oleander. In full bloom May 4, 1894,—Oscar Fulton's dooryard, Welsh. W.

Vinca major. Periwinkle. April 1, 1894, brought by Mrs. O. Fulton from Hawkeye Ranch, eight miles northwest of Welsh. W.

AQUIFOLIACEAE. HOLLYWORTS.

Ilex opaca Ait. Holly. In the woods on the bayou southeast of the home of Mr. Louvier, January 27, 1894. Leaves, thick, oval, spinescent. Not flowering at this season of the year. Specimen was 20 feet high. W.

Ilex opaca Ait. Variety, *integra*, according to Wood's Botany. The leaves differed from the preceding by being entire, very few spinescent, and more oval and smaller. In bloom in Oscar Fulton's dooryard, Welsh, April 22, 1894. W.

ASCLEPIADACEAE.

Acerates paniculata Desfn. A green Milkweed. In bloom May 2, 1894, near Oscar Fulton's road-gate, Welsh. W.

AURANTIACEAE.

Citrus vulgaris Risso. Bitter Orange. In bloom March 28, 1894; several trees, 15 feet high, growing on south side of Oscar Fulton's home in Welsh. W.

BROMELIACEAE.

isia usneoides L. Long Moss. Spanish Moss. Black Moss. Growing ·ofusion on the trees along the bayou west and south of Welsh, forming ng tufts or gray festoons. G.

CAPRIFOLIACEAE.

ra japonica. Chinese Honeysuckle. The full blown flower was pre- ne by Wade Spurgeon, January 23, 1894. W.
ra sempervirens Ait. Trumpet Honeysuckle. In full bloom in L. O. ls south of Welsh about two miles, April 14, 1894. W.

COMMELYNACEAE.

cantia virginica L. Spiderwort. Growing wild in Oscar Fulton's y 3, 1894, in bloom at this time. W.

COMPOSITAE.

um fimbriatum. Sneezeweed. In bloom May 3, 1894, in Oscar Ful- s southwest of Welsh. W.

CONIFERAE.

australis Mx. *Pinus palustris* Mill. Long-leaved Pine. Southern Pine. ıe. Hard Pine. Great forests of this valuable tree abound in the d northern parts of Calcasieu Parish, Louisiana, and extend northward ı along the Calcasieu and Sabine Rivers, but are rapidly disappearing great lumbering industries of this region.
taeda L. Loblolly Pine. Old Field Pine. The specimen examined was e, probably 50 or 75 feet high, standing in a plowed field on Hawkeye ed by Mr. Prentiss, northwest of Welsh about eight miles.
'*um distichum* Rich. Bald Cypress. Quite common in the bayous and margin of the lakes in Calcasieu Parish, Louisiana.

CORNACEAE.

uniflora Walt. Swamp Tupels. Gum Tree. Numerous tall trees along west and south of Welsh. W.

CRUCIFERAE.

ca arvensis (L) B. S. P. Charlock. Wild Mustard. In full bloom, 7, 1894, in Oscar Fulton's garden in Welsh. B. B.

CUPULIFERAE.

ıs virens Ait. Live Oak. Growing at Welsh. W.
ıs aquatica Mx. Water Oak. Growing at Welsh. W.

EUPHORBIACEAE.

rbia corollata L. Flowering Spurge. Growing on the school ground, y 2, 1894, when it was in flower. W.
gia sebifera L. Tallow tree. A large tree, growing by the front gate 'ulton's residence yard, May 4, 1894. W.

GERANIACEAE.

stricta L. A wood sorrel. In bloom on the school ground at Welsh,)4. W.

IRIDACEAE.

orentina. Orris-root. Flowering specimen mounted March 27, 1894, · Fulton's front yard. W.
·*chium bermudiana* L. Variety *anceps*. Blue-eyed Grass. Flowering found growing north of Welsh, April 1, 1894. W.

JUGLANDACEAE.

Carya olivaeformis. Pecan. Large tree, 60 feet or more in height, growing in Oscar Fulton's orchard, and in bloom May 3, 1894. W.

LEGUMINOSAE.

Baptisia alba R. Br. A Wild Indigo, growing on the school grounds in Welsh, and in flower May 2, 1894. W.

Baptisia serenae Curtis. A Wild Indigo, in bloom March 28, 1894, along the street north of the home of Mr. Earel in Welsh. W.

Trifolium repens L. White Clover. In full bloom, January 21, 1894, in Oscar Fulton's pasture. W.

LILIACEAE.

Allium mutabile Mx. A wild onion growing in the woods of L. O. Hills south of Welsh, and in bloom April 14, 1894. W.

Allium striatum Jacq. Thus called in Wood's Botany. But in Gray's Manual, called *Nothoscordum striatum*, Kunth. In bloom in Oscar Fulton's pasture, January 21, 1894.

Lilium canadense L. Yellow Lily. In bloom May 11, 1894, in Oscar Fulton's dooryard. W.

Yucca filamentosa L. Bear's Thread. A large specimen about 8 feet high, growing near south side of Oscar Fulton's home in Welsh, and in bloom May 4, 1894. W.

LINACEAE.

Linum sulcatum Riddell. A flaxwort specimen in bloom found growing on the west side of the school yard in Welsh, March 3, 1894. W.

LOBELIACEAE.

Lobelia nuttalii DC. Growing on the schoolo ground in Welsh, May 2, 1894, when specimen examined was in flower. G.

LOGANIACEAE.

Gelsemium sempervirens Ait. Yellow Jessamine. In bloom January 21, 1894, by Oscar Fulton's front yard gate in Welsh. W.

Spigelia marilandica L. Pink-root. In bloom April 14, 1894, in L. O. Hill's woods two miles south of Welsh. W.

LORANTHACEAE.

Phoradendron flavescens Nutt. American Mistletoe. Specimen procured from some of the deciduous trees in Oscar Fulton's pasture January 27, 1894. G.

LYTHRACEAE.

Punica granatum. Pomegranate. In bloom May 3, 1894. Specimen about ten feet high, growing in Oscar Fulton's orchard in Welsh. W.

MAGNOLIACEAE.

Magnolia grandiflora L. Big Laurel. In bloom April 22, 1894, at Prentiss' Hawkeye Ranch, from which specimen was secured through the kindness of Mrs. Oscar Fulton. W.

MALVACEAE.

Malva papaver Cav. Poppy Mallow. Its bright red flowers were in full bloom May 2, 1894, on the school ground in Welsh. W.

Modiola multifida Moench. In bloom May 2, 1894, by sidewalk along street by Mr. Hebert's home in Welsh. W.

MELIACEAE.

Melia azedarach L. Pride of India. Erroneousy named by the people of the locality, "Umbrella Tree", and "China Tree". An ornamental tree growing in the corner of the door yards or at the street corners; several in Welsh. Specimen in flower April 15, 1894, in Oscar Fulton's pasture not far from the north side of his house. W.

OLEACEAE.

Fraxinus americana L. White Ash. In bloom April 22, 1894, at Oscar Ful-'s place in Welsh. W.

Jasminium sombac. Jessamine. Cape Jessamine. Very fragrant. Specimen bloom May 3, 1894 at Mr. Heald's home in Welsh. W.

Ligustrum vulgare L. Privet Prim. Growing in front yard at Hotel Hanna the town of Jennings, Louisiana, May 6, 1894, when specimen was in flower. W.

Olea fragrans. Specimen in bloom given to me January 19, 1894, by Miss ne Miles of Welsh, and called by her China or Tea Olive. W.

ONAGRACEAE.

Gaura angustifolia Mx. Specimen in bloom growing on the school ground Welsh, May 2, 1894. W.

Jussiaea repens L. Specimen in bloom, May 2, 1894, growing on the school unds in Welsh. W.

Oenothera sinuata L. An Evening Primrose. In bloom March 28, 1894, along sides of the street north of Mr. Earll's home in Welsh. Native. W.

Oenothera vinosa. An Evening Primrose. In bloom March 31, 1894, grow- along the track of the Southern Pacific Railway in Welsh. Probably from lifornia. W.

PALMACEAE.

Sabal adansoni Guern. Growing along the bayou west of Oscar Fulton's ne at Welsh. As there were no flowers in bloom while I was there, I found it icult to determine this species, the description in Wood's Botany being very f. Is it possible that it may be *Chamaerops hystrix* Fraser? Palmetto.

PORTULACACEAE.

Claytonia Virginica L. Spring Beauty. In bloom February 3, 1894, in the thwest part of Oscar Fulton's pasture. W.

ROSACEAE.

Crataegus apiifolia Mx. A Hawthorn. In bloom February 10, 1894, Oscar ton's pasture at Welsh. W.

Crataegus aestivalis T. & G. Apple Hawthorn. In bloom January 21, 1894, Oscar Fulton's woods west of Welsh. W.

Fragaria vesca L. Strawberry. In bloom January 27, 1894, in Oscar Fu-'s garden in Welsh. W.

Prunus caroliniana Ait. Cherry Laurel. An evergreen. In bloom February 1894. Tree about 30 feet high growing in northeast corner of Oscar Fulton's ryard in Welsh. A handsome ornamental tree. W.

Prunus chicasa Mx. Chickasaw Plum. In bloom February 1, 1894, in west l of Oscar Fulton's orchard in Welsh. A native of the South. W.

Prunus umbellata Ell. Blossoms out before the leaves and very fragrant. A ge tree 15 or 20 feet high. In Oscar Fulton's pasture west of his orchard in lsh. W.

Rosa canina. Dog Rose. In bloom January 21, 1894, in Oscar Fulton's front ryard in Welsh. Said to bloom every month in the year. W.

Rubus trivialis Mx. Southern Dewberry. In bloom, February 10, 1894, in woods on the west side of Oscar Fulton's bayou southwest of Welsh. W.

Rubus villosus Ait. High Blackberry. In bloom February 10, 1894, in the ods on the west side of Oscar Fulton's bayou southwest of Welsh. W.

RUBIACEAE.

Chiococca racemosa. A shrubby vine. This was the only indoor plant that xamined. Clinging to supports before the west window of, and inside, the m occupied by myself in the home of Oscar Fulton. It was in bloom nearly winter. Specimen mounted January 28, 1894. Neither Gray nor Britton and wn mention it. Wood's description is very brief. It was known in the Fu.- home as Manetto. I am not certain of its identification.

Houstonia coerulea. Variety, *minor.* Dwarf Pink. Innocence. Bluet. In bloom, January 22, 1894, along the walk leading from the home of Oscar Fulton to the schoolhouse. W.

Mitchella repens L. Partridge Berry. In bloom, April 14, 1894, in L. O Hill's woods south of Welsh. W.

SALICACEAE.

Salix babylonica L. Weeping Willow. In bloom March 31, 1894, in south east part of Oscar Fulton's dooryard. W.

SAPINDACEAE.

Acer rubrum L. Variety, *tridens.* Swamp Maple. Growing in the bayou near the bridge south of Welsh. Examined May 5, 1894. W.

Aesculus pavia L. A Horse Chestnut or Buckeye. Examined April 14, 1894, in L. O. Hill's woods south of Welsh. W.

SAXIFRAGACEAE.

A Saxifrage growing on the school ground at Welsh, and in bloom May 2, 1894. I seem not to have made a closer identification.

SCITAMINEAE.

Canna discolor. Canna. Indian Shot. In bloom May 13, 1894 in Oscar Fulton's front yard in Welsh. W.

SCROPHULARIACEAE.

Pentstemon pubescens Sol. A Beard Tongue. In bloom on the school ground in Welsh, May 2, 1894. W.

SOLANACEAE.

Solanum carolinense L. Horse Nettle. In bloom May 2, 1894, in the street by home of Mr. Herbert in Welsh. W.

Solanum dulcamara L. Nightshode. Bittersweet. Fellonwort. Known here at Welsh as Bridal Wreath. Flowers, white. Vining along the front porch of Oscar Fulton's home in Welsh. Brought a specimen home with me to Winfield, Iowa, which has grown vigorously during the twelve years since its transplanting. B. B.

URTICACEAE.

Ficus carica. Common Fig. Several trees of good size in Oscar Fulton's orchard in Welsh, yielding considerable fruit. W.

Morus rubra L. Mulberry. Trees about 20 feet high. In bloom January 21, 1894, in southwest corner of Oscar Fulton's dooryard in Welsh. W.

Ulmus americana L. White Elm. In leaf the latter part of March, 1894, Growing by front gate before Oscar Fulton's home in Welsh. W.

VERBENACEAE.

Verbena multifida. A Vervain. In bloom January 23, 1894, and given to me by Wade Spurgin, whose home was a few miles north of Welsh. W.

Verbena teucrioides. A Vervain. In bloom May 2, 1894, growing near the steps leading to the front door of Oscar Fulton's home in Welsh. W.

A vervain that I could not identify fully with the Botanies at hand. A shrub about 4 feet high in Oscar Fulton's dooryard in Welsh, blooming May 2, 1894. Doubtless a native of the South, which our northern botanies have not included.

VIOLACEAE.

Viola obliqua Hill. Meadow or Hooded Blue Violet. In bloom January 27, 1894, in Oscar Fulton's pasture. B. B.

Viola ————. Doubtless a southern species that my botanies did not fully describe. Flower, pale purple and smaller than the preceding. Presented to me January 19, 1894, by Miss Belle Singleton, one of the pupils attending the public school of Welsh.

DOLOMITE AND MAGNESITE WITH REFERENCE TO THE SEPARATION OF CALCIUM AND MAGNESIUM.

BY NICHOLAS KNIGHT AND WARD H. WHEELER.

The estimation of calcium and magnesium in a mineral or rock is frequently necessary and seems like a simple matter, yet a great deal of work has been done on the subject, and different views are held as to the best procedure. The method that he has become accustomed to is doubtless the best for the individual analyst or teacher. Some of the methods, however, seem to be more simple and direct, and therefore less likely to lead to error than other processes which have been devised.

*Richards developed a method for the separation of calcium and magnesium where the substances are somewhat equal in amount, as in dolomite, and his method differs in some important particulars from those commonly employed.

To the solution of calcium and magnesium chlorides, Richards adds three grams of ammonium chloride, then oxalic acid and sufficient hydrochloric acid to keep the calcium in solution. A drop of methyl orange solution is next added as an indicator, and dilute ammonia slowly, with constant stirring to alkaline reaction. Lastly an excess of ammonium oxalate is added.

In applying this method, we found some difficulty in getting all the magnesium precipitated. Indeed four successive crops were obtained. This was doubtless due to the large amount of ammonium oxalate employed. One advantage claimed for it is the small amount of magnesium precipitated with the calcium, which in two determinations was:

1. .0011 Mg O equivalent to .42 per cent of the whole.
2. .0013 Mg O equivalent to .54 per cent of the whole.

Average .48 per cent of the whole.

In our experiment with this method we obtained .0028 Mg O equivalent to 1.24 per cent of the whole.

By what seems to us a simpler method, which will be explained later we found only .08 per cent MgO equivalent to .37 per cent of the whole, and in a number of instances we obtained .11 per cent MgO equivalent to .51 per cent of the whole.

We afterwards repeated the experiment and obtained .13 per cent. On re-dissolving this and re-precipitating we found only .01 per cent. A second time we obtained only .07 per cent, which when re-dissolved and re-precipitated gave no residue, and a third time we found no magnesium had precipitated.

*Zeitschrift für Anorg. Chemie July, 1901.

(1). Wolcott Gibbs conducted a series of experiments by which he concluded that it is more convenient to precipitate magnesium from a boiling concentrated solution with microcosmic salt instead of in the cold with disodium phosphate. The mean of four determinations with pure crystalized magnesium sulphate was .06 2-3 per cent. too high in MgO. While by the addition of ammonium chloride, it was reduced to .03 1-3 per cent. too high. Two analyses were next made by precipitating the boiling solution of disodium phosphate, after the addition of ammonium chloride. The result was .58 per cent, too high in MgO. When the precipitate thus obtained was dissolved in hydrochloric acid and re-precipitated with ammonia, the result was only .05 per cent, too high in MgO.

(2). Gooch and Austin conducted a valuable series of experiments, the object of which was to determine when results too high in magnesium are obtained, whether such results are due to mechanical occlusion in the crystalline phosphate, or to a variation in the magnesium ammonium phosphate, obtaining a product richer in ammonia and poorer in magnesium. They used microcosmic salt as the precipitant and obtained a salt $(NH_4)_4Mg(PO_4)_2$ to a greater or less extent with the ideal magnesium ammonium phosphate, $MgNH_4PO_4$, which would give a result too high in magnesium. To obtain the ideal salt, the first precipitate must be dissolved in hydrochloric acid and re-precipitated with ammonia. The authors commend the method of Gibbs of using microcosmic salt as the precipitant, and claim that by boiling the solution from three to five minutes the ideal salt is readily obtained.

We have repeated the separation of calcium and magnesium by the method described on page 127 of the Proceedings of the Iowa Academy of Sciences of the Year 1903, and still commend its accuracy and simplicity. The solution of ammonium oxalate was prepared by dissolving 10 grams of the purest obtainable crystals in 275cc of distilled water. The amount in a cubic centimetre was thus easily known. To insure the greatest possible accuracy, the precipitant should not be taken from a stock solution, but should be made up as required, on account of the solvent action upon glass. The solutions of calcium and magnesium chlorides were heated to boiling and kept at that temperature while the theoretical amount of the ammonium oxalate solution necessary to precipitate the calcium was added, and then two to four centimetres additional. After standing at least eight hours, the precipitate was filtered off. The filtrate was tested with one or two centimetres of the ammonium oxalate solution to learn if all the calcium was precipitated which was usually found to be the case. We thus learned that it did not seem necessary to add sufficient ammonium oxalate to change all the magnesium chloride into oxalate on account of the supposed solubility of calcium oxalate in magnesium chloride. It is doubtless true that in precipitating magnesium an excess of ammonium exalate does no harm, contrary to the teaching of some of the text-books, but an excess of ammonium salts simply retards the precipitation of magnesium. It is therefore unnecessary to remove the ammonium salts by heat before precipitating the magnesium.

1. Am. J. Science 3. 5. 114. 1873.
2. American J. Science 4. 7. 187. 1899.

The precipitate from the ammonium oxalate, consisting of the calcium and possibly a small amount of magnesium need not be washed as the small quantity of magnesium that is present will not be precipitated a second time with the calcium. For the same reason in a specimen of rock where the calcium is greatly in excess of the magnesium, a second precipitation is not necessary.

In the case of dolomite, the precipitate is dissolved on the paper with a small quantity of warm dilute hydrochloric acid, and the calcium is a second time precipitated with ammonia and a little ammonium oxalate, the magnesium now remaining in solution. The filtrate can be added to the main flitrate which contains the bulk of the magnesium. These filtrates should be concentrated if necessary. Care must be exercised in washing the precipitated calcium oxalate, which we have found to be appreciably soluble in hot water, less so in cold water, but it is best washed in cold water, to which a little ammonium oxalate has been added. On account of this solubility, it is better to wash the calcium oxalate on the filter rather than by decantation. In the analysis of Iceland Spar, washing the precipitated calcium oxalate is unnecessary as there are present with the precipitate only ammonium salts which the heat will afterwards volatilize.

The somewhat concentrated filtrate containing the magnesium is precipitated, while cold with a salution of disodium phosphate with constant stirring, and about 25cc. of ammonia water is added. It is allowed to stand 24 hours before filtering. *Lawrence Briant found that by violently shaking for ten minutes in a stoppered bottle all would be precipitated. Time, however, is not usually an object in such analyses, as other work can be in progress while the precipitate is standing.

Should there be present with the normal magnesium ammonium phosphate more or less of the other salt $(NH_4)_4Mg(PO_4)_2$, it would only be necessary to dissolve in hydrochloric acid and re-precipitate with ammonia.

We have found in hundreds of analyses of pure magnesium sulphate that very seldom do we get too high a result by precipitating as before described with disodium phosphate, and the same appears to be true of dolomite, although in the latter substance it is more difficult to know what is the real content. The occasional high result can be explained by imperfect washing of the precipitate.

In estimating the phosphoric acid in disodium phosphate with "magnesia mixture", the average student will more frequently obtain too high a result, but this seems to be the case when a large excess of the mixture has been carelessly added and the precipitate has been imperfectly washed. Our experience on the whole would tend to show but little necessity for a second precipitation.

Microcosmic salt is considerably more expensive than disodium phosphate, but doubtless the difference in the cost would ordinarily not be considered.

*Crooks Select Methods, page 51.

Concerning the small amount of magnesium that may come down with the calcium; the usual washing of the precipitate with hot water might remove an amount of calcium equal to the weight of the precipitated magnesium, and this amount would be afterwards precipitated with the magnesium. One source of error might almost completely balance the other and a satisfactory result would thus be easily attained. However, we do not practice or advocate such a procedure.

Treadwell-Hall in their work on quantitative analysis, page 71, call attention to an error quite often made by beginners. If all the calcium is not precipitated, it will come down with the magnesium and the total result will be too low. In order to separate the calcium from the mixture of the two phosphates, the precipitate after standing 12 hours is filtered, washed, dissolved in a small quantity of hydrochloric acid, and ammonia is added until the solution is alkaline. It is then strongly acidified with acetic acid, heated to boiling and precipitated with a boiling solution of ammonium oxalate. After 12 hours, the calcium oxalate is filtered, washed with hot dilute acetic acid and determined as calcium oxide. The filtrate is evaporated to dryness, the ammonium salts driven off, the residue dissolved in a little dilute hydrochloric acid and precipitated as usual. The reactions involved are represented by the following equations:

$3CaCl_2+2Na_2HPO_4=Ca_3(PO_4)_2+4\,NaCl+2HCl.$

$MgNH_4PO_4+3HCl=MgCl_2+NH_4Cl+H_3PO_4.$

$Ca_3\,(PO_4)_2+6HCl=3CaCl_2+2H_3PO_4.$

The acetic acid prevents any precipitation either of the calcium or magnesium until the ammonium oxalate is added to precipitate the calcium. If the magnesium ammonium phosphate is changed to the pyrophosphate, the acetic acid does not prevent the precipitation of the magnesium and the separation cannot be effected.

The equation in this case is Mg $+4HCl\quad 2MgCl_2+H_4P_2O_7.$

The equation is similar for calcium.

The pyrophosphoric acid slowly adds water and becomes $H_4P_2O_7+H_2O2H_3PO_4$.

The occlusion of ammonium oxalate by calcium oxalate.

In a private communication from Dr. Gregory P. Baxter, of Harvard University, he states that he has not published the results of his research upon the occlusion of oxalic acid and ammonium oxalate by calcium oxalate and that his results though somewhat unsatisfactory, pointed to no appreciable occlusion. Our test was as follows: We removed ammonia from a flask and Liebig condenser by distilling water through for an hour, or until the distillate gave no color with Nessler reagent. Then we added the well-washed calcium oxalate precipitate from a gram of the dolomite to the flask with 500 cc. of distilled water and 50cc. of alkaline permanganate solution. 300cc. were distilled off and 50cc. of the distillate gave scarcely a trace of color with Nessler solution. The same result was obtained whether the calcium oxalate was tested before drying, or whether it had been heated strongly with the blast lamp. The oxalate had been slowly precipitated from a boiling solution by constant stirring.

If one looks for all the substances that have been found in dolomites, free and combined water, organic matter, alkalis S. SO_3, TiO_2, P_2O_5, Sro and BaO, these in addition to the silica, ferrous and ferric iron, and alumina, and determines all the constituents present, it would constitute a somewhat complicated analysis, and would afford a large variety of practice.

The estimation of the carbon dioxide by the Bunsen method continues in favor in our laboratory. The amount of carbon dioxide obtained in the specimen of argillaceous limestone, which was the subject of the co-operative analysis by the two government officials was 30.59 per cent. and 30.77 per cent. One of our students obtained 30.76 per cent. before the results were published in the February number of the Journal of the American Chemical Society.

Magnesite—

A. The calcium was precipitated according to the method of *Scheérer. A half gram of the powdered mineral was changed to the sulphate. Alcohol was added to the aqueous solution until a persistent cloudiness was produced. After standing some hours all the calcium sulphate is precipitated. If too much alcohol has been added, some of the magnesium sulphate will also be precipitated, in which case the two sulphates are dissolved in water and the calcium is precipitated with alcohol or with ammonium oxalate.

B. The magnesite was dissolved in hydrochloric acid and an attempt was made to precipitate the calcium with ammonium oxalate, and making a double precipitation. There was obtained .23 per cent of calcium oxide more by method A than by B. It is evident, therefore, that when the amount of magnesium is relatively large method A is to be preferred.

An analysis of the magnesite resulted:

$MgCO_3$	98.43 per cent.
$CaCO_3$	1.22 per cent.
SiO_2	0.19 per cent.
	99.84 per cent.

The specimen was purchased of the dealers and its locality was not ascertained.

*Crooks Select Methods, page 52.

LOGARITHMIC FACTORS FOR USE IN WATER ANALYSIS.

BY W. S. HENDRIXSON.

Every chemist who does work in the analysis of water frequently has occasion to calculate over data given in terms of compounds and grains per gallon, to ions per liter or parts per million. Frequently he must carry out the reverse processes and convert his ions per liter into grains of compounds per gallon in order to make his results more comprehensible to the non-technical mind. Such operations are likely to be vexatious and time-consuming.

Having recently had occasion to re-calculate the data of many old analyses in order to have them in modern terms, I have worked out a system of logarithmic factors to facilitate the work. Since I know of no other such factors I deem it worth while to offer them to the Academy for record in the Proceedings that they may lighten the work of others. I am quite aware that there are already published logarithmic factors in plenty for the calculation of chemical analyses. In the lists examined, however, many of the factors required in the work referred to have been found wanting. Tables for the conversion of grains per gallon into parts per million are, also, not wanting. No table is known to me by which one may convert grains per gallon of compounds into parts per million in ions. Moreover, according to a recent determination of the Bureau of Standards, the ratio that has been used for grains per gallon to parts per million contains a large error. According to the Bureau of Standards one grain per U. S. wine gallon equals 17.117967 parts per million. For four place or even five place logarithms it may be taken as 17.118, and its logarithm is .23345.

The two columns of logarithms require little explanation. The first contains the logarithms of chemical factors that are required in the recalculation of the analytical data in the analysis of water. For example, for calcium in calcium carbonate the factor is 40.1÷100.1 and its logarithm is .6027. In the second column are the logarithms of the chemical factors plus the logarithm to convert grains per U. S. gallon to parts per million; that opposite calcium carbonate being .8361. Is it hardly necessary to state that one obtains compounds corresponding to ions by subtracting the appropriate logarithms from the logarithms of the ions.

In the calculation of the logarithms of this table the international atomic weights for 1905 have been used. Five place logarithms were used in the additions and subtractions, and the final logarithms taken to the nearest figure in the fourth decimal place. Four place logarithms are quite sufficiently accurate for such calculations.

Ca in $CaCO^3$	.6027	.8361	Fe in $FeCO^3$	.6833	.9168
Ca in $CaSO^4$	.4691	.7025	Al in Al^2O^3	.7245	.9580
Ca in $H^2Ca(CO^3)^2$	.3934	.6268	Cl in $CaCl^2$	.8053	.0388
Ca in $CaCl^2$	.5577	.7912	Cl in $MgCl^2$	.8717	.1052
Ca in CaO	.8542	.0876	Cl in NaCl	.7825	.0159
Mg in $MgCO^3$	.4605	.6940	Cl in KCl	.6769	.9103
Mg in $MgSO^4$	.3060	.5394	SO^4 in $CaSO^4$	.8485	.0819
Mg in $MgCl^2$	.4077	.6411	SO^4 in $MgSO^4$	.9018	.1353
Mg in $H^2Mg(CO^3)^2$	.2213	.4547	SO^4 in Na^2SO^4	.8298	.0632
Mg in MgO	.7807	.0142	SO^4 in K^2SO^4	.7411	.9745
Mg in $Mg^2P^2O^7$	.3399	.5734	SO^4 in $BaSO^4$	.6143	.8478
Na in Na^2CO^3	.6380	.8714	SO^4 in SO^3	.0791	.3126
Na in $HNaCO^3$	.4381	.6716	CO^3 in $CaCO^3$	.7777	.0112
Na in Na^2SO^4	.5109	.7444	CO^3 in $MgCo^3$	.8520	.0855
Na in NaCl	.5955	.8290	CO^3 in Na^2CO^3	.7524	.9859
Na in Na^2O	.8706	.1041	CO^3 in K^2CO^3	.6373	.8708
K in K^2CO^3	.7529	.9864	CO^3 in $FeCO^3$	.7141	.9475
K in K^2SO^4	.6523	.8858	CO^3 in $H^2Ca(CO^3)^2$	.8694	.1028
K in KCl	.7200	.9534	CO^3 in $H^2Mg(CO^3)^2$	.9138	.1472
K in K^2O	.9193	.1528	CO^3 in $HNaCO^3$	.8536	.0871
K in $HKCO^3$	.5921	.8255	CO^3 in CO^2	.1347	.3681
K in K^2PtCl^6	.2073	.4407	NH^4 in NH^3	.0248	.2583
Fe in Fe^2O^3	.8449	.0783	NH^4 in N	.1091	.3426

PERIODICAL LITERATURE IN IOWA ON THE SUBJECT OF CHEMISTRY.

BY W. S. HENDRIXSON.

Two years ago the author published in the proceedings of the Iowa Academy of Science a list of the chemical periodicals, then present in the libraries in the State. The purpose was, of course, to make known the presence of these periodicals to chemists in the state who have occasion from time to time to use them for reference purposes. Since that date many changes have occurred. Some periodicals have been dropped; more have been added, and many partial files have been made more nearly or quite complete. It seemed best, therefore, to offer a revised list for publication in the Proceedings of the present year.

It is no easy matter to determine just what publications should have mention in such a list and which should be excluded. It would require too much space to include all periodicals and proceedings of scientific societies which contain a few chemical papers. It has been thought best to include only periodicals devoted mainly to chemistry as a science. For the most part the proceedings of general scientific societies, and periodicals devoted chiefly to technology have been omitted. The list does not include fragments of periodicals, consisting of only a few volumes, unless those periodicals are now being received.

So far as known the books of any set mentioned may be used for reference in the libraries which contain them, and for the most part they may be borrowed by non-residents under suitable restrictions. In a few cases sets belong to the private libraries of chemists connected with the institutions designated, but this does not preclude their use by other chemists.

The chemists of the state are to be congratulated that it is no longer necessary to send to eastern libraries for books from sets of the great and much used periodicals. With half a dozen exceptions such periodicals may now be had within the borders of the State. I shall name some prominent exceptions in the hope that the wants may be supplied in the near future by such libraries as may be able to command the resources. The following are suggested:

Gazetta Chimica Italiana.
Journal fur Praktische Chemie.
Monatshefte fur Chemie.
Annales de Chemie et de Physique.

In the following list the extent of the files is indicated by years and the libraries in which the periodicals are to be found are designated as follows:

State University of Iowa, S. U. I.; State Library, S. L.; Iowa State College, I. S. C.; Iowa College, I. C.; Morningside College, M. C.; Drake University, D. U.; Cornell College, C. C.; Coe College, Coe; Simpson College, S. C.; State Normal, S. N.

Annalen der Chemie, Liebig's.
S. L., 1832-1895; S. U. I., 1887—

American Chemical Joúrnal.
S. U. I., complete; I. C., complete; I. S. C., complete; S. N. 1894—; C. C., 1900—; S. C., 1902—

American Journal of Science.
S. U. I., complete; S. L., complete; I. S. C., complete; C. C., complete; I. C., 1852—1891; M. C., 1892—

Bulletin de la Societe Chimique de Paris.
S. U. I., complete; D. U., 1895—; I. C., 1904—

Berichte der Deutschen Chemischen Gesellschaft.
M. C., complete; I. C., complete; S. U. I., 1898—; D. U., 1895; C. C., 1898—

Annalen der Physik und der Chemie, Poggendorff, Wiedemann.
S. U. I., nearly complete.

Beiblatter, Annalen der Physik und der Chemie.
S. U. I., complete; S. L., complete.

Analyst, The.
I. S. C., 1890—

Chemisches Centralblatt.
S. U. I., complete; I. C., 1897—

Chemical News.
S. U. I., complete; I. S. C., 1883; D. U., 1894; C. C., 1900—

Comptes Rendus.
S. U. I., 1897—; S. L., 1897—

Jahresbericht uber die Fortschritte der Chemie.
S. U. I., complete.
I. C., 1895—; I. S. C., 1897—; M. C., 1900—; D. U., 1901—; S. U. I., 1903—; S. N., 1904—
S. N., 1904—

Journal of the Society of Chemical Industry.
S. U. I., complete.

Journal of Physical Chemistry.
S. U. I., complete; M. C., 1895—

Journal of the Chemical Society of London.
S. U. I., complete; S. L., complete; I. C., 1863—; M. C., 1871—; I. S. C., 1890—

Zeitschrift fur Analytische Chemie.
S. U. I., complete; I. S. C., complete; I. C., complete.

Zeitschrift fur Anorganische Chemie.
S. U. I., complete; I. C., complete.

Zeitschrift fur Electrochemie.

S. U. I., complete.

Zeitschrift fur Physikalische Chemie.

S. L., complete; S. U. I., 1893—

There are several periodicals devoted to physiological Chemistry, sets of which are owned, so far as known, only by the library of the State University. They are the following:

Beitrage zur Chemischen Physiologie und Pathologie, complete.

Biochemische Centralblatt, complete.

Jahresbericht fur Thierchemie, complete.

Journal for Biological Chemistry, complete.

Zeitschrift fur Physiologische Chemie, complete.

ACTION OF BROMIC ACID ON METALS.

BY W. S. HENDRIXSON.

About two years ago I submitted to the Iowa Academy of Science* a communication on the action of chloric acid on metals, in which it was shown that in some cases the metals dissolved without the evolution of any gas, the action apparently being the oxidation of the metal and the immediate formation of salts from the oxides and the excess of chloric acid, and the hydrochloric acid produced by the reduction of chloric acid. In the cases of some metals there occurred at the same time oxidation of the metal and the evolution of free hydrogen. In fact, in the cases of the alkali metals and magnesium the latter action preponderated.

In the above series of experiments it was observed that there was no apparent reaction between the excess of chloric acid and the small amount of hydrochloric acid formed by reduction. Only a trace of free chlorine was observed in one or two cases. Later experiments in connection with the work on bromic acid showed that the action of chloric acid in concentrated solution, on hydrochloric acid of far greater concentration than could have been obtained by the reduction of chloric acid in the experiments cited, was very small. Though these experiments have not yet been carried as far as designed, a few results may be stated, for their own interest and to make clear the striking difference between the results obtained in the study of the action of chloric acid and of bromic acid on metals.

Hydrochloric acid and chloric acid were mixed so as to give them in the mixture the respective concentrations, twice normal and four-tenths normal, or as 5 to 1, which is the ratio in which they preponderatingly react upon each other. The mixture was placed in a glass-stoppered distilling flask whose side arm was connected with a ten-bulb column containing potassium iodide. The flasks were filled with carbon dioxide and placed in the dark closet where the temperature was practically constant at 20°. At the end of definite periods the chlorine set free was aspirated over into the potassium iodide solution until all color disappeared from the first flask and the liberated iodine was titrated in the usual way. The amount of chlorine set free at the end of 2 hours was .0148 gram; at the end of 8 hours, .0256, and at the end of 17 hours, .0302 grams. These and other experiments showed that practical equilibrium was attained after a few hours, if allowance be made for the chlorine removed by diffusion into the second flask and absorption in the potassium iodide solution.

*Proceedings, 1904, p. 150.

It is evident that the interaction of chloric acid and the small amount of hydrochloric acid produced in the study of the action of chloric acid on metals, is insignificant. On the other hand the hydrochloric acid produced may itself be effective in dissolving small quantities of some metals, such as magnesium and zinc. In the action of bromic acid on metals the results were quite different, as anticipated. As is well known hydrobromic and bromic acid readily react upon each other in the proportion of five molecules of the former to one of the latter setting all the bromine free. The hydrobromic acid is, therefore, removed, as formed with the liberation of bromine, but the bromine may itself react upon the remaining metal.

The bromic acid used in the following experiments was made by Kahlbaum. It was as usual colored by bromine, which was aspirated off in a vacuum before use. It was free from sulphuric acid and its freedom from the acids of chlorine was tested by determining the ratio of silver to silver bromide, in which weighed amounts of pure silver were precipitated with hydrobromic acid made by reducing the bromic acid. Three experiments gave the following proportions:

1. Ag : AgBr :: 100 : 174.09
2. Ag : AgBr :: 100 : 174.01
3. Ag : AgBr :: 100 : 174.19

The average is 174.09 and the theory 174.08.

The concentration of the acid was found to be 1.25 normal, and in most of the experiments it was used undiluted. In the experiments the apparatus was such as to permit the reaction of the acid and metal to take place in carbon dioxide, in order to avoid any oxidizing action of the air. The acid was placed in a glass-stoppered distilling flask whose side tube entered the neck of another distilling flask and its tip was placed just under the surface of a solution of potassium iodide. To the side arm of the second flask was connected a bulb column to absorb the last traces of bromine, in the dilute potassium iodide which it contained. The whole apparatus was filled with carbon dioxide, the stopper removed, the metal dropped in. It was placed in a dark closet and allowed to remain, usually several hours or till the metal was all dissolved. The bromine was then all aspirated over into the potassium iodide with a stream of air under about 50 mm. pressure. The free iodine was titrated with sodium thiosulphate and the corresponding bromine calculated.

In the experiments described below the bromine is usually a little smaller than required by theory, on the supposition that the hydrobromic acid produced in the oxidation of the metal reacts with bromic acid thus: $5HBr + HBrO^3 = 3H^2O + 6Br$. The deficiency amounts on the average to about 5 per cent. and may be due to one of two causes or both. The bromine set free may act directly upon the remaining metal forming a bromide which would again react with bromic acid, or there may result the formation of some hypobromous acid, which would not distil over under the conditions. I regret that I have not been able to pursue the subject farther and hope to return to the study in the near future.

Action of Bromic Acid on Zinc. The zinc was of excellent quality, of the same lot described in the paper on chloric acid. Any adherent oxide was removed with emery paper. Pure zinc and bromic acid give off no hydrogen. The zinc simply goes into solution rapidly and at ordinary room temperatures. The liberated bromine was aspirated into potassium iodide solution as described and the free iodine was titrated.

1. .6010 grams of zinc gave .2792 grams of bromine. Calculated .2979.
2. .5131 grams zinc gave .2371 grams of bromine. Calculated .2512.
3. .5808 grams zinc gave .2664 grams bromine. Calculated .2841
4. .4252 grams zinc gave .2048 grames bromine. Calculated .2093.

Action of Bromic Acid on Aluminum. Unlike zinc aluminum dissolves in bromic acid with the liberation of considerable quantities of hydrogen. It was not deemed practicable to determine the hydrogen and the bromine set free in the same experiment. In one experiment in which .2082 gram of aluminum and 23 c. c. of bromic acid of sp. gr. 1.25 were taken the hydrogen began to come off at the rate of about one bubble to five seconds, increased to one bubble a second and then gradually decreased, practically ceasing after several hours, when 0.1578 gram of the metal had dissolved. The hydrogen collected corresponded to .0225 gram or about 15 per cent of the metal dissolved.

Two other experiments in which the bromine alone was determined resulted as follows:

1. .3113 grams aluminum gave .4632 grams bromine.
2. .3278 grams aluminum gave .4836 grams bromine.

If the hydrogen was given off in the same proportion as in the above experiment the theoretical amount of bromine corresponding to the metal used in reducing the bromic acid are 4753 and 4994.

Action of Bromic Acid on Magnesium. Bromic acid acts upon magnesium with the rapid evolution of hydrogen at first, but soon free bromine begins to appear and the hydrogen then slackens as in the case of the solution of aluminum. In one experiment .1315 grams of magnesium wholly dissolved and gave off a volume of hydrogen corresponding to 37.6 per cent. of the metal.

Action of Bromic Acid on Iron. Iron rapidly disolved in bromic acid, going as might be expected into the ferric condition. Apparently in the beginning of the reaction there is a trace of hydrogen set free, but it is entirely too small to admit of measurement.

1. .2469 grams of iron gave .2132 grams of bromine. Calculated .2116.
2. .2479 grams of iron gave .2088 grams bromine. Calculated .2125.

Action of Bromic Acid on Sodium. As stated in a former paper chloric acid is only very slightly reduced by sodium or potassium amalgam. Bromic acid on the other hand is very readily reduced. In two experiments in each of which 5 c. c. of 1.25 normal acid were diluted to 20 c. c. and treated with 20 grams of 2 per cent amalgam, very little hydrogen appeared at first and no bromine. After about an hour the hydrobromic acid produced was determined by weighing as silver bromide. The amounts of bromine in the silver bromide were .1507 and .2196 grams.

Action of Bromic Acid on Cadmium. Cadmium slowly dissolves in normal bromic acid, no hydrogen being set free. The bromine set free corresponded very nearly to the theoretical supposing that two atoms of bromine correspond to one of cadmium.

1. .4507 gram cadmium gave .1240 gram bromine. Calculated .1280.
2. .2935 grams cadmium gave .0840 grams bromine. Calculated .0835.

Action of Bromic Acid on Copper. The copper used was in the form of fine wire of the electrolytic metal. It dissolves readily, and its solution takes place readily in the approximately normal acid.

1. .3706 grams copper gave .1976 grams bromine. Calculated .1864.
2. .3766 grams copper gave .2020 grams bromine. Calculated .1894.

Action of Bromic Acid on Tin. Tin is slowly dissolved by bromic acid. There remains a very small amount in the form of undissolved oxide. The results indicate that the metal goes into the stannic condition.

1. .3365 grams of tin gave .1796 grams bromine.
2. .3307 grams tin gave .1768 grams bromine.

The calculated amounts of bromine supposing the tin completely oxidized to the stannic condition are .1809 and .1778 grams.

Some study was made of the action of bromic acid on silver and bismuth. Both are oxidized quite slowly in the cold. Of course the silver is soon coated with insoluble silver bromide and bromate. So far as investigated the action of bromic acid on silver is quite analogous to that of chloric acid; that is, the ratio of the silver as AgBr is to that as $AgBrO^3$ as 1 to 5. Of course no bromine is given off in the cases of the other metals, the bromic acid being fixed as silver bromide as fast as formed.

The action of bromic acid on metals is about as might have been anticipated from the knowledge of the action of chloric acid. Bromic acid is a less stable acid and more readily acts as an oxidizing agent. The cases are fewer in which it acts upon metals with the liberation of hydrogen, and the amounts of hydrogen are smaller in proportion to the metal attacked. Its ready reduction by hydrobromic acid, causes the latter to be oxidized as fast as formed with the liberation of practically the full equivalent of bromine demanded by the equation already given.

SOME VARIANT CONCLUSIONS IN IOWA GEOLOGY.

BY J. E. TODD.

Having been a resident in southwestern Iowa for many years and conversant with several localities in the state of geological interest, the writer has naturally followed closely the publications of the present Survey treating of them.

In casting about for a subject for some different conclusions which had come to his mind, he thought first of "corrections and additions", but as that savored rather of too much self-assurance the milder form was preferred. Since the writer does not arrogate superior knowledge in the cases, he would simply state his views and leave them to whatever acceptance they may deserve.

1. The first variant conclusion concerns a *folding of Carboniferous rocks in Fremont county:*

Prof. Udden, in his admirable report, has fallen into the same error as Dr. White did more than 30 years before. The writer was in the region a few years before he discovered the mistake. It was finally made perfectly clear by a visit to the west side of the Missouri river at Jones Point, just above the mouth of the Weeping Water. There is a fine exposure there which seems to have escaped Meek and Hayden. It shows a dip of 4° or 5° SSE. which carries over 100 feet of strata, which are exposed in the summit of an anticlinal about a mile north, entirely below the level of the river, in less than that distance. Taking the direction from that point to the break in the strata south of Wilson's quarry perhaps half a mile, near the south line of section 23, T. 70, R. 43, we find the axis of the fold is N. 60° E.

The fold is so sharp that the heavy limestone strata and nearly the whole of White's section at Wilson's quarry, or Udden's X, XI, and XII, passes entirely out of sight before the south line of section 26 is reached. At Nebraska City a section corresponding somewhat to XIX has been noted by many and Meek gives a record of Croxton's boring (Hayden's Final Report of Neb. p. 105) to a depth of 344 feet starting 13 feet above high water mark. By a comparison of exposed sections with the record of the boring, it seems fairly clear that the top of the sandstone exposed in the bottom of Wilson's quarry and also in the large quarry opposite Haney's, (Udden's sections X and V, though he fails to report this at either point) is at the depth of 238 feet or 210 feet below low water of the river there. This sandstone is what White called the base of the Upper Carboniferous. The sandstone which he records as exposed at Plum Hollow (Thurman now) and at Hamburg is not the same, but is probably that exposed at Wyoming, Nebraska, and Nebraska City, though

possibly those at the two northern localities may correspond to a sandstone down 90 feet in the boring. The fold is quite sharp at Jones' point and may become a fault on the Iowa side. At any rate there is no considerable dip in strata not more than half a mile apart.

The general fact of a southern dip was recognized by Owen, Meek and Hayden, Marcou, and other early explorers, but there seems not to have been a clear location of it, nor of its amount till the writer presented a paper which was published in the Proceedings of the Iowa Academy of Sciences, Vol. 1, part 1, p. 58. As that seems to have been overlooked, he adds more from it:

"Paleontological evidence seems to coincide with the conclusions from stratigraphy. Of the more than 100 species listed by Meek as found in Eastern Nebraska 20 are found north of the steep fold at Jones' point and not south; 47 are found south but not north, and 35 are found on both sides of the line."

Combining the section west of Nebraska City, at that point, including the boring (Fin. Rep. pp. 103, 101 and 105), section at Wilson's (White's Report on Iowa, Vol. 1, p. 358) the section at Rock Bluff and below Plattsmouth (Hayden's Report, pp. 95 and 93), we have the following:

	Section of Carboniferous Rocks in Southwestern Iowa.	Thickness.	Total.
16.	Blue, red and ash colored clays, with two layers of limestone 2 and 4 feet thick	19	19
15.	Yellow micaceous Sandstone	10	29
14.	Drab, ash, lead and chocolate colored clays or shales with a thin blue limestone	39	68
13.	Limestone in thin layers, light yellow and gray	12	80
12.	Shales, mostly gray, some red and blue with 5 thin layers of limestone and 4 of sandstone	185	265
11.	Bluish limestone, interstratified with black shales and 1 foot of coal near center	12	277
10.	Drab clays, enclosing 3 strata of limestone, 2—4 feet thick.	30	307
9.	Compact limestone, mostly thin-bedded and some layers stylolitic	20	327
8.	Drab clays, carbonaceous at two levels, and with 2 thin limestones	12	339
7.	Soft, fine-grained yellow sandstone, White's No. 1 at Wilson's	12	351
6.	Clays and slates, bluish and gray, with 3 or 4 limestones, one much the thickest sometimes 7 feet	45	396
5.	Limetones, yellow and gray, many *Fusilina,*	20	416
4.	Clays, ash and red with black shale in middle	5	421
3.	Yellowish soft sandstone	4	425
2.	Limestone, very fossiliferous	10	435
1.	Greenish and chocolate clays above and shales below	25	460

Level of the Missouri at Plattsmouth.

A careful comparison of sections on both sides of the River shows two anticlinals, the higher with its crest near Plattsmouth, the other about 1 1-4 miles above Jones' Point. Taking the top of the sandstone No. 7 of the above general section, we may represent the folds by the following:

TABLE.

	Omaha	Bellevue	LaPlatte	Plattsmouth	Rock Bluff	Kenosha	Summit	Jones' Point	Wyoming	Nebraska City
Altitudes above Missouri R.	16	12	23	128	91	38	78	62	212	237
Miles from Omaha	0	5	8	14	19	22	26	27	30	35

The above data was given in the paper in 1889 already referred to, but are here revised in statement.

2. In the Report on Plymouth county two points need modification. The first is the mistaking the chalky stratum of the Benton, now named Greenhorn for the Niobrara. Dr. Bain, in making the statement simply followed the interpretation which had been first made by Hayden, who named the Benton and Niobrara, and very naturally followed by all observers after him, with the exception of White and St. John, who wisely used other names.

The mistake was virtually corrected by Iowa geologists finding Benton fossils above the limestone in Sioux county. Iowa Geol. Surv. X. p. 114.

The other mistake grew out of the first, viz: the top of the chalkstone is taken for the bottom of the till or Pleistocene (Ia. G. S. VIII, p. 331). The thinness of the chalkstone was ascribed to glacial erosion consequently Cretaceous shales 50-60 feet thick in some places, and forming a distinct bench along the face of the bluffs in section 13, T. 91, R. 49, was called till. This is somewhat excusable because the clay was weathered to a structureless mass near the surface and it was well sprinkled with pebbles and boulders from the drift beds above which are comparatively thin and much stratified above. The Cretaceous clays are usually readily recognized by striking a pick into them. The clay a few inches from the surface is gritless and waxy.

3. Another variant interpretation concerns the exposure at the old site of Otis's mill on the Dakota side of the Big Sioux below Hawarden. The differences of reading are difficult to account for except by considerable changes in the exposure.

The Section given in Iowa Geol. Survey, Vol. VIII, p. 334, is as follows:

6.	Loess, sandy with many lime concretions	20	feet.
5.	Drift, new, fresh pebbles, yellow color, and with traces of soil at top	30	
4.	Old soil, black to drab, sandy	2	
3.	Sands, white to lemon yellow, very fine above, coarser and orange, below,	10	
2.	Niobrara, principally thin shelly limestone, with few chalky streaks	35	
1.	Shale, black to drab, with poorly developed laminations	20	117

The writer has more recently studied the locality with the following results:

Table of Exposures at Otis' Mill.

Top of hill back about 135 feet above river.

Grassy slope mostly loess though pebbles may show as high as the top of the exposure.

8.	Loess, apparently in situ, though probably slipped	8	8
7.	Till, yellowish, though bluish in places	22	30
6.	Slope with loess and yellow till mingled	15	45
5.	Dark fossiliferous soil or mud, *Planorbis* large and small, *Pisidium Cyrena*, *Limnea* 2 or 3 species, *Valvata*, *Unio*, large jaw of horse, rather larger than domestic, with three molars, thicker to south	7-3	48
4.	Yellowish loam and sand coarser below passing into gravel thicker northward	2-10	38
3.	Dark waxy shaly clay mingled with till above, shown at extreme south	4-0	58
2.	Bluish chalk, with hard shaly limestone interstratified, softer above and below passing into shale	18	76
1.	Shale, laminated, black and blue	12	88

Level of Big Sioux at medium stage.

The rational interpretation seems to be that Nos. 5 and 4 were deposited in an old bend of the river when its surface was about 40 feet higher than at present, the sand being the true river deposit, while the loam and dark mud record the accumulation after the bend had become a bayou. The slope which overlaps it and gives an impression of a second till is probably the caving and wash from the cut bank back. It is interesting to note that this bend would correspond to the Unio Terrace which Dr. Bain noted at several points, and considered pre Wisconsin. I can see no sufficient reason, however, for considering it very ancient.

4. Professor Wilder in his Geology of Lyon and Sioux counties, thinks he has found reason to locate the Altamont moraine east of Sioux Falls and of the Big Sioux further north, instead of south and west in a broad curve, west of Wall Lake as was done by the writer. There is not time now for discussion, but the writer wishes to reaffirm his former interpretation of the facts, with much confidence so far as concerns most of the moraine. Possibly a comparatively faint and early member may be traced along the line he indicates.

In this connection the writer would add that after a re-examination of the cuts along the Illinois Central and Sioux Falls, which were visited jointly by Bain, Leverett and himself, and treated by him in Proceedings of I. A. S. Vol. VI, p. 125, he returns to his former interpretation, viz: that they are all in an old terrace of the river. The terrace topography and the general character of the deposits are his main reasons, which time prevents giving here in detail.

5. Time permits the very brief discussion of only one more "variant". Prof. McBride, in his discussion on Clay and O'Brien counties (Iowa Geol. Survey, Vol. XI, p. 488), records 700 feet to water in a well east of Primghar and another 1,000 in Caledonia township, and apparently infers that the till probably goes to those depths. That is certainly deep enough to reach the Dakota, and it seems more rational to believe that 5-600 feet of that depth is Cretaceous. Similar records are frequently given in South Dakota, where it is clear that such is the case. In fact if no sand is found or noticed separating the till from the Cretaceous few can tell when the drill passes the line of separation. The concretions in the shale simulate closely in shape, hardness and frequency the boulders and pebbles in the till. And the till often has almost the same composition as the shale from which it has been mainly formed.

With this the writer would respectfully submit this paper to your candid consideration and kindly judgment, and only hopes that it may be of some service, if not to others, to himself, through criticism by others.

MORE LIGHT ON THE ORIGIN OF THE MISSOURI RIVER LOESS.

BY J. E. TODD.

My excuse for offering another paper on this well worn subject is my recently acquired familiarity with a deposit of Lake Dakota, which closely resembles loess, in structure and composition, and in its relations to underlying till and to recent channels. In short it seems to be a more recent and less extensive formation of the same sort.

The resemblances are so striking and its fluvio-lacustrine origin so unquestioned that a similar origin for the loess of the Missouri is strongly suggested.

THE TESTIMONY OF LAKE DAKOTA.

Lake Dakota was a body of water related to the James river in late glacial times, somewhat as Lake Pepin is to the present Mississippi, but much larger. It was about 110 miles long and 20 to 25 miles wide, with a depth at its maximum of more than 50 feet.

The glacial erosion had deepened and widened the valley toward the north so that in flooded stage the James river of that time, the muddy waters from the edge of the ice sheet a few miles further north, and from the surrounding slopes, poured into the basin more rapidly than they could escape through the narrower and stony portion of the valley near the south line of Spink county.

Near the southern end the channels, by which the ice sheet was drained before it had vacated the basin, which are now tributaries of the James, had been cutting channels into the till of depth approaching in some cases that of the present streams. The maximum flood doubtless attended the recession of the ice from the Antelope or Third, moraine, but was sustained or replenished from time to time during the occupation of the Fourth moraine.

It probably fluctuated in level with the seasons and was quite as much a river or cluster of rivers as a lake, for it formed no beaches, and yet eventually much of the basin was filled quite uniformly to the level of 1300 feet above sea level. The filled portion was left level as a floor over many square miles, while other portions were 25 or 30 feet lower, and in or near the principal channels where we may suppose the motion of the water may have prevented deposition, or when the water subsided erosion may have been greater, the surface of the loam deposit is still lower. Besides these deeper channels there are smaller ones nearly filled, only narrow winding sags in the surface of the plain, which apparently represent the condition of some of the deeper ones before they were washed out in the final drainage of the lake.

Again, many of these channels have sand and gravel deposits, underneath the loam, lining former channels cut in the underlying till, imitating similar deposits under the loess in such locations. The surface of the till, was not as rough before the deposition of the loam as the Kansan till was before the deposition of the loess, for the latter had been subject to longer and more vigorous erosion. Yet, let us remember, in the latter case the surface of the till is much rougher now than when the loess was laid down. There can be no doubt in the light of many observations, that the roughness of both the till and the loess has been greatly intensified by ravine cutting, as I explained in my paper on "Degradation of Loess".

This loam or silt so strongly resembling loess, is of a cream color, not so yellow or rusty looking as the loess, it is of about the same fineness, is composed mostly of well rounded quartz grains, and shows no sand or coarse particles except toward the base, exhibits the same vertical cleavage so often mentioned of the loess, and is usually similarly unstratified. In some localitiees there is quite regular alternation of thin loamy and clayey layers composing several feet of its depth, but often 15 or 20 feet thickness of the loam may appear without distinct stratification. Pebbles are as rare on the plain of Lake Dakota as in the loess region of western Iowa. Only a very few knolls of bowldery drift stick up like islands above the loamy plain.

No fossil shells appear in the loam and fossils of any kind are very rare. Prints of leaves have been reported in its lower layers, but the report is not very trustworthy.

Calcareous concretions with cracked interior like "Loess kindchen", are not infrequently found, and also ferruginous pencil-like ones like those of the loess, but all these characteristics may be considered natural results of the physical nature of loam.

The deposit shows more frequently efflorescent salts on the surface of its exposures, especially toward its base, but this is easily explained by its youth and consequent less complete leaching.

We may therefore sum up the resemblances between the lacustrine loam of Lake Dakota and the loess of the Missouri valley, as follows:

Its fineness and composition, its destitution of aqueous fossils and others as well, its general absence of stratification, its prevalent vertical cleavage, and the prevalence of cracked calcareous and of pencil-like ferruginous concretions.

Its deposition like a blanket over high and low surfaces of the till, often with a washed surface upon the latter and with sand and gravel deposits along the larger channels cut in its surface; the absence also of any distinct barrier to hold back the depositing waters.

It differs from the loess most in its color, larger proportion of soluble salts and in the more even surface of the underlying till, also in the more extended level form of its upper surface with its nearly horizontal position. These differences are in degree, however, rather than in kind, and can perhaps all be accounted for by differences in age, thickness and height above base-level. Besides, the loess having a much larger extent

doubtless includes the deposition in several basins at different levels as well as in connecting channels, and these of different ages. The "flats" of Lake Dakota are extensive because young, but traces of similar flats may be found, particularly in east central Missouri and in northwestern Iowa and eastern Nebraska, remote from larger streams. Even in southwestern Iowa clear examples of them are found. Tabor, Iowa, is upon one including nearly a square half mile. On the same level as shown by railroad surveys is a similar area two miles north and again north and south of Hilldale. Cases like these could be multiplied from the same and other divides of that region. (See also the similar cases recognized and described by Dr. Udden, Ia. Geol. Survey, Vol. XIII, p. 128.) These areas present true flats with imperfect surface drainage, and some with abrupt shoulders and abrupt descents into ravines. The altitude of this level is about 1250 feet above the sea and considerably lower than points a few miles northeast next to the Missouri river bottom land, which are doubtless built up considerably by wind action. This is evident from the surface form and its position southeast of a wider area of bottom land, a location analogous to that of sand dunes built on the general level of the loess plain east of West Point, Neb.

It is sometimes urged that in fluvio-lacustrine deposits there would necessarily be much coarse material mingled with fine and this has been in the minds of some an argument against the aqeous origin of loess, but Lake Dakota shows that there is no such necessity for the central portions of the deposit. There is more or less coarse material near the margins and in the lower portion, but apparently coarse material becomes stuck in the mud at the bottom before it has gone very far. Exceptions would of course exist where there was floating ice, but evidently this was absent while most of the loam was being deposited.

The lacustrine loam of Lake Dakota, therefore, furnishes a strong argument, by analogy, for the aqueous origin of the mass of the Missouri River loess.

THE TESTIMONY OF RIVER TERRACES.

We next proceed to show how the analogy of common river terraces points in the same direction.

In the cases already considered there is quite an abrupt change from coarse material upward into massive loam, sometimes with considerable interstratification of coarse materials between. A similar order is the rule in the structure of river terraces generally.

It may be seen in the flood plain of any stream of size carrying silt in quantity, like the Missouri, Platte, and most streams of the loess region, wherever there is enough coarse material obtainable sufficient to form the foundation.

The coarse material attests the velocity of the stream in its rising stage and while it retains its channel. When it overtops its banks and covers more or less of its flood plain, especially when it spreads from bluff to bluff it attains a lacustrine character and deposits its suspended

silt widely and rapidly, as was so well exemplified in the flood of 1881 in the Missouri River (See Report of Mississippi River Commission, 1881, p. 136, and Bull. G. S. A. Vol. 12, p. 489.) This lacustrine stage was attained even with a greater slope than that of the stream at low water.

Similar lacustrine conditions obtain more or less in the deposition of the loam capping bottom lands generally. The more perfect the lacustrine character and the more rapid the deposition the more massive, or unstratified the character of the deposit.

Some cases of this action in a small way in Mills Co. will be found; Plates VI. and V. Vol. XIII, Iowa Geol. Survey. The terraces of the Glacial epoch are heavily capped with loam indistinguishable from loess. This is particularly true of high terraces of the Missouri above Pierre where the loam is sometimes 30 feet thick. It appears on several terraces, high and low, at Pierre and many points below (See Bulletin 158, U. S. G. S. p. 137.) also (Missouri Geological Survey, vol. X, p. 135.) The southern part of Sioux City south of the Stock Yards and east also is evidently a terrace judging from its topography. Here the bulk of it is loess resting on a base of coarse sand and is almost certainly of river deposition and yet indistinguishable by structure and composition from the higher loess further northeast. Similar relations occur at Kansas City, not to mention others.

At St. Joseph, Mo., the loess hill southeast of the depot is probably also a remnant of a terrace judging from its altitude and its coarse stratified base. The high loess around the water works is more likely to be of aeolian origin at least above. These localities are finely illustrated in Miss Owen's papers in American Geologist, April, 1904 and May, 1905.

An important feature of this relation, which should not be overlooked, is the not very infrequent interstratification of the coarse and fine material, sometimes for the thickness of a few feet. It shows more or less in nearly all river terraces. Similar mingling of coarse material with the lower portion of the loess has been reported from many localities, by many observers. Winchell from Minnesota, McGee from northeastern Iowa, and Udden from southwestern. The writer has noticed it repeatedly in South Dakota and Nebraska. The interesting case of interloessial till found by Dr. Bain and the writer in northwestern Iowa though somewhat different, attests just as strongly the deposition of a portion of loess at least in water (Iowa Geol. Survey, Vol. V. p. 284. Proc. I. A. S. II. 20-23.) Prof. Shimek's strictures must miscarry until he can find a mass of till from which the case shown in the plate could have slipped. And the writer feels fully as confident as Bain expresses himself, that it is as high as any till in the vicinity. Moreover the plate itself shows no sign of slipping.

But the higher loess, i. e. that which reaches up to the higher levels, not limited by any terrace relief, also sometimes rests upon deep deposits of gravel and sand, as found above Council Bluffs a few miles at Mynster Spring, and north, also near Hinton station south, and north of Omaha, west.

The gradation downward of loess into gravel is illustrated often n northeastern Nebraska, near the Missouri and southwestward along wo or three higher and perhaps older lines of drainage, marked by owlder trains below the loess and by valleys with unusual sand deposits n them traversing the loess in a southeasterly direction. They seem o have been related to the Dakota ice sheet either of the Iowan or ery early Wisconsin stage. These are briefly discussed in Bulletin 58, U. S. G. S., p. 61. More recent study has shown more clearly the owlder trains connected with them.

That advocates of the general aeolian origin of the loess admit this oess like capping, the following references show. (Udden, Iowa Geol. Survey, 1900 XI. pp. 265-6; Calvin, Ditto. p. 446; McBride, Ditto. 483.)

Hence we have an almost insensible gradation from the common alluvial terrace to the heavy loess deposits, hence it would seem if some claim that there is an essential difference in the method of deposition anywhere, it should be their peculiar duty to draw the line of distinction and establish the criteria of distinction.

TESTIMONY OF DIFFERENT SIMILAR DEPOSITS.

Another argument may be derived from the variety of deposits hich resemble loess in fineness and distribution. One writer has ecently found three distinct loess deposits in southwestern Iowa on e same hillside (Journal of Geology, XII, p. 716.) Udden admits that red clay or gumbo" may be a loess and that this and typical loess sensibly grade into one another (Iowa Geol. Survey, XI, p. 258, and III, p. 167.)

Now it would not be difficult to admit that quite different deposits ould be formed by wind action, if the gathering grounds of material ere different, but to get two or more in the same locality, would require ther a change of climate or a marked difference in the surrounding urface. We can easily understand how loess of different ages should e much alike, for the range in size of particles carried by wind is mall, comparatively. We can believe that there might be a gain in layey character more remote from the bare surface contributing materal, we can see how the more clayey might have a brighter and more ermanent color, and that colors might vary with the color prevalent n the original source. But how by the aeolian hypothesis can be xplained the occurrence of different strata of considerable thickness, learly delimited and in close contact? And the difficulty is still more ggravated if they are of limited lateral extent, and more yet if there re three or more.

To the aqueous hypothesis, on the contrary such facts present no ifficulty. We have already noticed that it properly devolves upon the dvocates of the aeolian hypothesis to show cause for claiming that ost of the Missouri River loess is of aerial deposition when so many imilar deposits are unquestionably of aqueous origin.

TESTIMONY OF FOSSILS.

The patient and painstaking work of Prof. Shimek has done much in this direction, and we must acknowledge, that wherever a deposit contains only land shells, which were clearly deposited with the formation, we must admit that it is quite certainly of aeolian deposition.

But there are some uncertainties in the practical application of this principle. It must be admitted that there are unquestionable aeolian deposits including loess-like formations sometimes of great extent and thickness. There are such in the Black Hills. Such I have long recognized in the high points east of Haney's in Mills county, Iowa, and there are such at many points along the bluffs north of there including the high pinnacles in Plymouth county which Dr. Bain so ably differentiated from the surrounding loess at lower levels.

Nevertheless, for the wider application of the aeolian theory we must judge it unproven.

Not only do the arguments already presented point in a contrary direction, but there are several considerations which weaken his argument for the wider field and until they have been counterbalanced we must retain the older and more consistent view.

1. The loess is acknowledged by all who are familiar with it to be subject to step faulting often to great depths. This is due to similar conditions to those which cause crevasses in glacier rapids. It occurs particularly on steep slopes when the lower portion has been rendered plastic by moisture. It is conceivable that molluscs frequenting the surface, might in this way be introduced to considerable depths. It may seem impertinent or unkind to even whisper that a trained observer should mistake such for fosslis, but it is only emphasizing the need of scientific caution in view of the next consideration.

2. It is very difficult to distinguish disturbed and rearranged loess from that originally deposited.

Loess washed by the rains into crevices, basins, or other depressions or that which flows as mud is one hour plastic and mobile as water, the next has so reset that it is almost impossible to discover the former bounding surfaces. I know of no sure way unless some foreign object or some unusual tint be present to indicate.

In this way may not shells have been entombed so gently that opercula and eggs may have been preserved as Prof. Shimek reports?

Most of his fossil localities are on hillsides and near streams Until we have evidence from the central masses of loess, i. e. deep below a flat surface, where fissuring or wash could not be postulated, there will be room for reasonable doubt. The wisdom of such suspension of decision is the more apparent, when we remember how the majority of exposures in apparently equally favorable locations are found to be non-fossiliferous. Especially is this true of localities remote from main streams as Prof. Shimek himself testifies.

Time permits but a word or two concerning two other points of minor importance.

TESTIMONY OF RIVER BLUFFS.

One of these is that if the Missouri loess is supposed to be mainly derived by the winds from the sand bars of the Missouri River as Shimek states, (Bulletin, Lab. of Nat. Hist. of Univ. of Iowa. Vol. V. No. 4, pp. 318 and 373) there should be a marked excess of loess on the east side, for the same reasons that sand dunes, which are surely aeolian are found best developed to the east and south of wide stretches of large river valleys. (Bul. 158, U. S. G. S., p. 64.) This is because northwest winds are most efficient in this work in this region, though we may admit that winds from other directions have some effect. In this latitude westerly winds are prevalent the northwest in winter and the southwest in summer. Hence if the loess is from the river bars there should be a very perceptible preponderance of it east of the Missouri. The slight excess claimed by Shimek and admitted by advocates of the aqueous theory seems fairly explained in this way, but this leaves the great mass of loess very imperfectly accounted for, and its nearly equal development east and west sadly out of proportion to the directions and relative strengths of winds, as Prof. Wright well claims. (Amer. Geologist, XXXV. p. 236.)

If the aeolian hypothesis is ever to explain the mass of Missouri loess, the origin should be sought rather on the arid plains further west, yet in that case there is met the difficulty of accounting for so much greater depth near the river. Moreover, there should be a steady increase in clayey character toward the east.

TESTIMONY OF ROOT MARKS.

Again, there is an evidence which Richthofen, the first advocate of the aeolian theory, made much of, but which later advocates, for some reason, seldom mention. It is this, minute rootmarks very generally fill the loess from top to bottom to which fact perhaps the vertical cleavage is partly due. He ascribed these to grasses growing a few feet above and therefore found in them evidence that the surface had gradually risen by dust accretion. This was shown by the writer to have little if any significance in that direction so far as American loess was concerned, because grasses and other prairie plants were shown to send down roots 15, 25, even in some cases 60 feet. (Proc. A. A. A. S., 1878, pp. 236-7.) But they do furnish testimony opposed to Prof. Shimek's plea for the aeolian theory. He postulates timber-clad hills for the habitat of his land shells. (Proc. I. A. S., VI. p. 108.) And he explains the disappearance of tree trunks and other marks of vegetation by postulating the very slow accumulation of the dust. (Bull. Lab. Nat. Hist. S. U. I., V. No. 4, p. 320.) But if this were the case, how can the absence of large tree root-marks be accounted for? Wood and leaves may decay and the processes of the surface obliterate every trace but we cannot believe that of the rootmarks when we find the minute ones so perfectly preserved. May it be that they have been overlooked? Take the Council Bluffs localities; certainly that remarkable stratum

of shells should show some trace of the large roots of trees if any were ever there. The writer has searched in vain for any not easily referred to the present surface, nor to his knowledge has any other observer reported any. If therefore the former existence of trees must be discredited, then also the great age of the shells may be, unless the explanation offered for their recent introduction given on a previous page is disproved.

But time forbids further discussion at present. Possibly a word of forecast concerning probable untimate conclusions may be of interest and of possible help to direct observation. Imagination is often a serviceable scout in the advance of Science, even if she may sometimes err in her vision.

CONCLUSION.

It seems not improbable that the mass of the Missouri River loess will remain credited to aqueous forces. The absence of fresh-water molluscan remains may be explained by the coldness of waters from the north, and the muddineses of the same as also of those from the west. Perhaps those existing in some remote pools or streams were destroyed in transportation or were too heavy to be carried to higher or distant localities.

Very considerable portions of the loess will be proved to be the work of wind; the pinnacles along the eastern verge of the trough of the Missouri in Iowa including possibly Council Bluffs in part, and the higher ridges south of the Missouri in northern Nebraska, also in less degree south of the Platte, the extensive blanket covering the broad divides especially those between larger streams, may be placed under this head. The aqueous loess in its early bare condition afforded abundant source for comparatively rapid accumulation. Nor should the difficulty of distinguishing the aqueous from the aelian form be an objection to this view. We all know how difficult it is to distinguish sand deposits laid down by these two agencies, particularly if they have been subject to surface action. How much less then should we expect to see differences when the material is finer grained and more homogeneous.

GEOLOGY OF THE CORINTH CANAL ZONE.

BY CHARLES R. KEYES.

Plates XIV-XV.

(Abstract.)

At the present time when we are hearing so much about the Panama canal we almost forget that there are other important constructions of this kind in other parts of the world. Of the famous canals there is one about which little mention appears to be made. This is the Corinth ship canal in Greece. It is of special geological interest on account of the fact that it gives a superb cross-section of a sea-beach dating from middle Tertiary times, and continuing to the present time.

The location of the Corinthian canal is shown on the cut; Plate XIV. A view of this canal is given in Pl. XV taken from the Athens and Corinth railroad bridge which spans the canal at a height of 170 feet.

Although open only within the last decade and a half the Corinth canal is a very old project. The first proposal for this canal was made 600 years B. C. by Periander, Tyrant of Corinth. The Roman emperors Julius Caesar and Caligula became greatly interested in the scheme; but it remained for the emperor Nero to prosecute the work in earnest. Since his time many persons have continued the work.

The canal is about four miles long. The cut is 280 feet deep at the highest point; and about 260 feet wide at the top and 70 feet at the bottom. The water is 26 feet deep.

The old beach deposits appear to be Middle or Late Tertiary sandstones chiefly. Near the center there is reached beneath these deposits a very hard rock which is exposed for a distance of a mile. This is probably of Cretaceous age. The extreme induration is characteristic of the Cretaceous rocks of the neighborhood.

LIME CREEK FAUNA OF IOWA IN SOUTHWESTERN UNITED STATES AND NORTHERN MEXICAN REGION.

BY CHARLES R. KEYES.

Twenty years ago one of our most prominent Iowa scientists, Mr. Frank Springer, announced the discovery of a typical Lower Burlington fauna at Lake Valley, in southern New Mexico. A year ago I had occasion to state before this Academy that this Lake Valley limestone is of wide extent. Now, at Lake Valley there exists beneath the limestones carrying he abundant crinoids of the Lower Burlington a massive, yellow, magnesium limestone very much like the Chouteau limestone of Missouri, and beneath this green and then black shales in all respects like the Kinderhook shales at Burlington. Beneath this section there is in southwestern New Mexico and southeastern Arizona a limestone formation which is highly fossiliferous, and which carries the common fossils, many forms which we are very familiar with in Iowa. The most abundant forms are those unique types which collectively are known as the Lime Creek fauna, now famous the world over through the discussions and descriptions of Professor Calvin.

It is now pretty well agreed by Tschernychew, Williams and other authorities, that this Lime Creek fauna is Mid Devonian in age, and that it appeared earlier in the West than in the East. In New York it is found in the Late Devonian portion of the section. Its recent discovery in the Southwest is of great interest.

In southwestern United States the Paleozoic sequence has been little understood. Of the five great systems which constitute it in the general section only the Carboniferous rocks have become familiar. Until within the past two or three years Cambrian, Ordovician, Silurian, and Devonian rocks have been practically unknown in New Mexico. Now all four systems are found to exist here. Peculiarity of areal distribution has been the chief cause for their escaping notice. They form a narrow belt of tilted beds striking northwestward from El Paso.

In the Franklin Mountains north of El Paso where magnificent sections, 4,000 feet in height are to be seen the entire Paleozoic succession is finely exposed. The Carboniferous limestones appear to rest directly upon the Silurian and Ordovician. Thus far no Devonian beds have been recognized. Farther westward the Devonian formation begins to appear and by the time the Arizona line is reached it has attained a thickness of over 300 feet. Although not yet reported the Devonion beds no doubt occur in a score or more of the mountain ranges of southwestern New Mexico and southeastern Arizona.

Among the most characteristic Lime Creek species found in this region are:

Spirifer hungerfordi Hall.
Spirifer orestes Hall & W.
Spirifer fornicula Hal.
Spirifer whitneyi Hall.
Strophodonta demissa (Conrad).
Strophodonta calvini Miller.
Strophodonta perplana (Hall).
Atrypa reticularis (Linn).
Rhipidomella livia (Billings).
Strophonella coelata Hall.
Ortholetes chemungensis Hall.
Productella speciosa Hall.
Cyrtina hamiltonensis Hall.
Cyrtia cyrtiniformis (Hall & W.)
Dialasma calvini (Hall & W.)
Pugnax pugnus (Martin).
Schizophoria striatula (Schlotheim).
Bellerophon sp ?
Loxonema sp ?
Acervularia profunda (Hall).
Acervularia davidsoni (Edwards & H.)
Pachyphyllum woodmani (White).
Cladopora prolifica (Hall & W.).
Cyathophyllum sp ?
Stromatopora erratica (Hall).
Melocrinus sp ?

The above forms are the most striking and the easiest indentified. There are a large number of others. A little work on the part of some one familiar with Devonian types of life and especially with the Iowa species, would, no doubt, establish a prolific fauna. It is a field worthy of attention.

ALTERNATION OF FOSSIL FAUNAS.

BY CHARLES R. KEYES.

Several years ago while studying the coal measures of Iowa and the neighboring states, it was suggested in a general way that the so-called Lower Coal Measures and the so-called Upper Coal Measures eventually might prove to be essentially contemporaneous.

In commenting upon the great erosion plane at the base of the Coal Measures it was stated that in the Iowa region at least for a very considerable period during the Kaskaskia epoch erosive agencies were actively at work on the land surface which extended southward about as far as the present city of Saint Louis. Shore deposits, sands and clays, were laid down immediately beyond the place just mentioned, while farther southward marine beds continued to be formed one above another conformably.

When a new period of depression set in, coal marshes were formed along the landward creeping shore-line. The more strictly marine deposits began to slowly extend farther and farther northward resting on the older calcareous beds as well as the earlier formed marginal areas of sands, clays, and accumulated vegetation. This process with many brief interruptions continued until the old shore-line had again gained its former place near the present Iowa-Minnesota boundary. The coal, or marginal, beds were formed at the same time as certain limy layers farther outward; and that all formations along any given horizontal line (nearly horizontal, but having a slight inclination to the southwest) were deposited contemporaneously. On a sinking coast the marginal sediments would have continually the later open sea deposits laid down upon them. The covering of the coal-bearing strata by the calcareous beds would constantly take place as long as the depression of the shore continued.

The "Lower" Coal Measures are not then a series of beds laid down previous to the deposition of the "Upper" Coal Measures. Each particular part of the former was deposited at the same time as portions of the latter farther seaward; the lines of contemporaneous deposition being nearly horizontal, yet having a common though slight seaward tilt. As a whole the "Lower" Coal Measures do actually lie beneath the "Upper" Coal Measures; but the line of separation is not a line drawn parallel, but obliquely to the planes of sedimentation.

More recently some instructive facts bearing upon the question have been brought to light regarding the faunas contained in the Kansas section. Previous results of very similar character were obtained in Iowa and Missouri a decade previous, and incidental mention made of them,

The results of the late Kansas work by Girty* and White are presented in tables giving the range of the fossil species. The vertical distribution is extended upward beyond the highest rocks of Iowa and Missouri.

Altogether, from the base of the productive coal measures in these states, from the bottom of the Des Moines series, through the Missourian series and the Oklahoman series, or to the top of the Marion formation in central Kansas, there are some 2,000 feet of strata. There are alternating limestone and shale formations which number about fifty. These 25 limestones and 25 shales have received distinctive names.

It is a well known fact that organic remains are abundant from the bottom to the top of the section. The remarkable feature of the Girty tables is that with few exceptions the fossils were obtained from only the limestone beds—the shales yielding few or no forms. In other words the fossils are practically in alternating formations. This alternation of limestones and shales is shown in the following list of formations beginning at the top of the section.

MID. CARBONIFEROUS.	Oklahoman S.	Marion formation
		Winfield formation
		Doyle shale
		Fort Riley limestone
		Florence flint
		Matfield shale
		Wreford limestone
		Garrison formation
		Cottonwood limestone
	Missourian Series	Eskridge shale
		Neva limestone
		Elmdale formation
		Americus limestone
		Admire shale
		Emporia limestone
		Olpe shale
		Barclay limestone
		Burlingame shale
		Howard limestone
		Severy shale
		Hartford limestone
		Calhoun shale
		Deer Creek limestone
		Tecumseh shale
		Lecompton limestone
		Kanwaka shale
		Oread limestone
		Le Roy shale
		Stanton limestone
		Lane shale
		Iola limestone
		Vilas shale
		Earlton limestone
		Chanute shale
		Drum limestone
		Cherryvale shale
		Dennis limestone
		Galesburg shale
		Hertha limestone
	Des Moines S.	Dudley shale
		Parsons limestone
		Bandera shale
		Pawnee limestone
		Labette shale
		Fort Scott limestone
		Cherokee shale

*Bull. U. S. Geol. Sur., No. 211, p. 77, 1903.

While some of the species from the limestones also occur in the shales, they are represented usually by so few individuals that they may be considered in the latter as purely accidental occurrences.

To the eastward the conditions of sedimentation are reversed. Shales predominate, with limestones intercalated. The shales are quite fossiliferous. Forms from the shales only sparingly occur in the limestones. The faunas of the limestones are very distinct from those of the shales, but among themselves are practically the same. Moreover, they are essentially identical with those from the limestones higher up in the Missourian series of Kansas.

Kansas shales have not been exhaustively examined for fossils. Those shale formations of the Missourian series which have been carefully examined carry the typical forms of the shales of the lower Des Moines and Arkansan series rather than the types of the Missourian faunas as generally known, which is the limestone fauna.

There is, then, in the Coal Measures of Iowa, Missouri, and Kansas an alternation of faunas corresponding to the alternation of lithologic units. There is a characteristic fauna of the limestone formations; and there is a characteristic fauna and a flora of the shale formations. The main reasons why the two faunas have not been differentiated are these: Little attention has been paid to the formational range of the organic remains. Comparative abundance of the invertebrates in each formation has not been noted. The tendency to list simply species has done nothing towards distinguishing faunas. As a result faunas which are really distinct and which should be kept entirely separate are merged. Critical examination of the biologic features as given in the literature of the subject indicate quite clearly that the faunas as usually recognized are composite faunas. Inquiry in the field shows that such faunas are in reality made up of distinct elements. These are not continuous through any considerable range, but alternate, much the same way as do the general lithologic characters.

Similar conditions of alternations of faunas have also led to very erroneous conclusions regarding the age of the different parts of the Cretaceous section in the southern Rocky Mountain region, to which attention has been recently called.

A CONTRIBUTION TO MADISON COUNTY GEOLOGY.

BY F. A. BROWN.

There is given below a typical or general section of the Missourian formation in Madison county, as given by Tilton and Bain.* It is mainly to the rocks of this stage that reference will be made in the present paper.

NO.	SECTION.	FT.	INS
20.	Limesone, yellow, earthty, thin layers, fusilina, aulopora and Productus	4	
19.	Shale, drab to yellowish	1	
18.	Alternating calcarean and shaly bands yellowish with Derbya-crassa,—Productus and spirifer planoconvexa	3	
17.	Dark shale	1	2
16.	Ledge of compact limestone	1	2
15.	Dark blue shale, many crushed Productus		6
14.	Black, very carbonaceous shale	1	
13.	Shale, argillaceous above, sandy below	4	6
12.	Limestone, coarse, divided by shaly partings	3	
17.	Shale, dark, in part very carbonaceous with band crowded with Chonetes. In places, the Chonetes are cemented into a band of limestone	8	
10.	Blue limestone, very fossiliferous, three bands separated by shale	3	
9.	Shale, dark above, lighter below	2	
8.	Marly. yellowish shale	2	
7.	Yellowish soft limestone becoming harder below	5	
6.	Thin layers of limestone shaly partings	12	
5.	Black slate and shale	3	
4.	Yellowish, earthly, calcareous beds	4	
3.	Limestone, with thin alternating bands of shale	12	
2.	Black shale	3	
1.	Band of limestone		6
	To continue this section to the base of the Missourian we have:		
5.	Sandy shale	15	
4.	Limestone weathering into nodular fragments	5	
3.	Shale parting		3
2.	Limestone, similar to number 4	4	
1.	Shale, blue to buff	2	

According to the authors of the report on the geology of Madison county, the foregoing constitutes a typical section from the top of the Des Moines stage to and including the base of the Fusilina limestone, which is number 20 of the section: Nos. 6, 7 and 8 of the above are the Winterset limestone. The following section is exposed at the quarries of the stone company at the town of East Peru.

10.	Yelelowish, marly shale, with Derbya and Phillipsia	3 or more	
9.	Limestone, yellow earthy—Allorisma	2	
8.	Shale		1
7.	Limestone, yellowish somewhat sandy	4	
6.	Shale, with numerous Choretes	10	
5.	Limestone, bluish with Conchoidal fracture	10	
4.	Shale parting		1
3.	Limestone, heavy bedded	4	1
2.	Shale, with Chonetes and Rhombopora	1	
1.	Limestone, bedded from 4 to 12-in.	6	

It seems probable, that number 10 of the quarry section at Peru corresponds with No. 8 of the general section, that Nos. 7, 8 and 9 are the equivalent of No. 7 of the general section, and Nos. 1, 2, 3, 4, 5 and 6 of the Peru quarry section can be correlated with No. 6 of the general section given above.

*Geology of Madison county, in VII Ann. Report Ia Geol. Surv.

If this be the case then the limestone at Peru is the equivalent of that found at Winterset (See Geol. Mad. Co. Ia. Geol. Surv. Vol. VII, p. 512). The writer has gone over the ground alone and in company with Mr. Herman Mueller, and he agrees with the writer that the Peru section should be assigned to the Winterset.

Now the top of the uppermost beds exposed in the Reed uarry, which is one-half mile west of the Peru quarry, is about 10 or 12 feet above No. 9 of the Peru quarry section, which is also exposed in Reed quarry.

As neither Mr. Mueller, Mr. T. E. Savage, nor the author have found any Fusulina while examining the Reed quarry beds above No. 9 of the Peru section and since there is thickness of 28 feet of strata between the top of the Winterset limestone and the base of the Fusulina limestone, according to Tilton and Bain, it seems probable that the Fusulina limestone is not exposed at the Reed quarry (See Mad. Geol. Ia. Geol. Surv. Vol. VII, pp. 525-529).

The writer does not hope to offer much that is new concerning the geology of Madison county, but he would call attention to a vein of coal of fair quality eleven inches thick, a short distance below the Earlham limestone (Nos. 3 and 5 of the general section).

Another feature not formerly mentioned is the glacial striations on the ledge in the Peru quarry. The striae run, as near as could be determined with a pocket compass, north 27° west, and a level board laid across the top of the ledge at right angles to the striations would perhaps show some of them to be two or more inches deep in the center and as much as two or three feet in width.

In some places the grinding has been carried on until the surface is almost as smooth as glass, again it is barely perceptible. There is a fair sample of this glacial work in the office of the Iowa Geological Survey at the Capitol.

The glacial deposits at Peru carry a very great number of limestone bowlders varying in size from small ones weighing one or two ounces to large ones weighing as much as two tons. Many of them are rounded and others show marks of glaciation. There are also the usual number of fossils of different kinds in that drift.

The writer has found a small specimen of Rhombopora hardly one inch long and as large as a small knitting needle, also a Derbya crassa scarcely one-half inch in diameter, which came out of the clay lying directly above the limestone at Peru.

An amethyst crystal one inch long, a specimen of iron ore and a species of favositid coral also were found in the gravel above the clay just mentioned.

Some small fish teeth were picked up from the sands of Middle river west of Winterset, but it may be that they were brought there, by the river from the Cretaceous farther north and west, rather than by the ice.

There is given below a list of fossils found in the Missourian formation in Madison county. Messrs. Tilton and Bain have been followed in so far as they gave the horizon of the fossil mentioned in their report.

Thanks are also due to Prof. T. E. Savage and Mr. Herman Mueller, for assistance in identifying fossils in the appended list. The number placed opposite the name corresponds with that of the bed in the typical section and indicates the horizon at which it may be found.

PROTOZOA.

Fusulina cylindrica. Meek & Hayden 20

COELLENTERATA.

Aulopora (probably *gracilis*). Keyes 10
Axophyllum rude. White and St. John 3
Chaetetes milleporaceous. Milne-Edwards and Haime ....Des M.
Lophophyllum profundum. Milne-Edwards and Haime ....X2&X4
Michelinia eugeneae. White ....
Syringopora multattenuata. McChesney 3

ECHINODERMATA.

Archaeocidaris agassizi. Hall ....5&X1
Hydreionocrinus mucrospinus. McChesney ....
Ulocrinus kansasensis. Miller & Gurley 6

MOLLUSCOIDEA.

Fistulipora nodulifera. Meek 6
Rhombopora lepidodendroides. Meek 6
Septopora biserialis. Swallow 6

BRACHIPODA.

Ambocoelia plano convexa. Shumard 18
Chonetes granulifer. Owen ....6&7
Chonetes mesolobus. Norwood and Pratten ....Des M.
Chonetes parvus. Shumard ....Des M.
Chonetes verneuilianus. Norwood and Pratten ....6,9&11
Derbya biloba. Hall & Clarke ....
Derbya crassa. Meek and Hayden ....7&8
Dielasma bovidens. Morton ....X2&X4
Hustedia mormoni. Marcon ....X2&X4
Mekella striato-costata. Cox X2
Productus cora. D'Orbigny 11
Productus costatus. Sowerby ....X2&X4
Productus longispinus. Sowerby ....X2,X4&11
Productus muricatus. Norwood & Pratten ....Des M.
Productus nebraskensis. Owen 6
Produstus punctatus. Martin 6
Productus semireticulatus. Martin ....
Pugnax uta. Marcon ....X2&X4
Reticularia perplexa. McChesney 3
Rhipidomella pecosi. Marcon ....X2&X4
Spirifer cameratus. Morton ....3,6&11
Spiriferina kentuckensis. Shumard ....X2&X4
Seminula argentea. Shepard ....X2,X4,X3&6

MOLLUSCA.

Allorisma subcuneatum. Meek & Hayden 7
Aviculopecten occidentalis. Shumard 18
Myalina kansasensis. Shumard 11
Myalina subquadrati. Shumard 11
Myalina swallovi. McChesney 11

GASTEROPODA.

Bellerophon (probably *carbonarius*). Cox ....X:
Naticopsis altonensis. McChesney ....X:
Pleurotomaria carbonaria. Norwood & Pratten ....
Straparollus catilloides. Conrad ....X:

CEPHALOPODA.

Nautilus. Sp. Undt. ....
Orthoceras cribrosum. Geinitz ....
Orthoceras rushense. McChesney ....

ARTHROPODA.

Phillipsia major. Shumard ....

The nomenclature of this list is in accordance with Mr. Stuart Welli used in his "Bibliographic Index of North American Carboniferous Invertebra (See Bul. U. S. Geol. Surv. No. 153.)

AN ATTEMPT TO ILLUSTRATE TIDES AND TIDAL ACTION.

BY JOHN L. TILTON.

Plate XVI.

The inspiration for this paper was due to Professor W. M. Davis, who, in an article published in the Journal of School Geography, Vol. 4, No. 7, discussed the "Illustration of Tides and Waves". This led me to think that here in an inland town where there is no opportunity for the student to observe tidal effects, there is a need for class illustration that I, at least, had been neglecting. I consequently drew a plan of what it seemed to me would meet the need and employed a local tinner to construct the apparatus. The piece proves very satisfactory and seems quite desirable not only to illustrate tidal waves in bays of various shapes, but also deposition of sediment under various conditions and the formation of ripples on sediment.

The tray is two feet long, one foot wide and five inches deep, the partitions three inches high, the entrances to B and E one-half inch wide. One end of the tray is occupied by a rectangular pan, A, having a handle within it, by means of which the pan may be pressed down into water in the tray causing the level of the water to rise; or the pan may be raised out of the water causing the level of the water in the tray to fall. B, C, D and E-F represent bays of different shapes; B and E-F, large bays with narrow entrances, C a bay narrowing toward its head, D an estuary. E-F has two entrances, so that the wave representing the tide arrives first through E and later through F. The illustration is varied and emphasized by nearly closing the entrance at E with a T-shaped piece of tin. The effects may also be further increased by closing the wide entrance to C by a piece of tin made to fit around the exposed ends of the sides of C. The volume of water that can flow in near F in a few seconds is not large partly because of the narrowness of the passage way and partly because of two rounded elevations each about an inch high placed six or seven inches apart in the bottom of the passage way.

If a little very fine sand is sprinkled along F and at the entrance of the bays the currents are not only rendered more noticeable, but the places of erosion and deposition become evident, allowing the student opportunity to test his judgment as to the effects, or to observe the effects as a basis for further study. In B the sand at the entrance is swept away by the swift current and spread over the wider parts of the bay beyond. Near the entrance of C a bar forms, the outer margin of which assumes a slightly crescentic shape. This illustration may be

varied by placing the sand at the head of the bay instead of at its trance. In D the sand is spread out along the channel. Near E are t deposits and channels due to the currents as the water flows in and o In the narrow passage way to F the erosion and deposition of the sa placed between the two partial obstructions illustrate river erosion a deposition; and, when E is partially closed, the current sweeping near F washes the sand into a hook-shaped bar.

If instead of very fine sand a coarser sand is used the further effe of sorting of material are illustrated. The effects may be further vari by removing A and then elevating and depressing that end of the tra

THE HOLDING AND RECLAMATION OF SAND DUNES AND SAND WASTES BY TREE PLANTING.

BY H. P. BAKER.

ORIGIN OF DUNES.

By a dune we mean a low hill of drifting sand usually formed on the sea-coast or shore of large inland lakes. Along the sea-coast the movement of the tide, the flow of which is more rapid than the ebb, tends to carry sand beyond the action of the waves, where it is caught by sea winds and carried up the beach to be piled in dunes and hills.

If the land winds are of greater frequency, duration or strength than the sea winds, the sands left by the retreating waves will be constantly blown back into the water, but if the prevailing air currents are in the opposite direction, the sands soon will be carried out of the reach of the highest waves and will be transported continually farther and farther into the interior of the land unless obstructed by high grounds, vegetation or other obstacles. So long as the sand is kept wet by spray or by capillary attraction it is not disturbed by air currents, but as soon as the waves retire sufficiently to allow it to dry it becomes the sport of the winds and is driven up the gently sloping beach until arrested by stones, vegetation, or other obstructions, and thus an accumulation is formed which constitutes the foundation of a dune. By successive accumulations they gradually rise to the height of 30, 50, 60 or 100 feet, and sometimes even much higher. The dunes once deposited are held together and kept in shape partly by mere gravity, and partly by the slight cohesion of the lime, clay and organic material mixed with the sand; and from capillary attraction, evaporation from lower strata, and retention of rain water.

In working through the sand hill country of western Nebraska, and through the dune region of the Columbia river it was an interesting thing to find that the sand of the dunes or hills was always moist a little below the surface. Even with moisture present strong winds instead of adding to the elevation of the dunes sweep off loose particles from their surface, and this, with others blown between the new-forming dunes build up a second row of dunes, and so on according to the character of the wind, the supply and consistence of the sand and the face of the country. In this way is sometimes formed a belt of sand dunes irregularly dispersed and varying much in height and dimensions and often times many miles in breadth.

DUNE MOVEMENT.

The rapidity with which dunes move inland varies from a few inches to a number of feet annually, depending upon the force of the wind and the location of the dunes with reference to interior obstruction. Studies have not been prosecuted to a sufficient extent in this country for us to make any definite statements as to rapidity with which dunes along our sea-coast or inland are moving, but observations made during an average season lead us to believe that depending upon the severity of the winds our dunes have about the same rate of movement as those in France and other countries. Bordering the Bay of Biscay in Gascony, France, there is a belt of sand dunes which vary in width from one-quarter to five miles,and cover an area of about 250,000square miles. Where these dunes are not fixed by grass and a group of trees they advance eastward at a mean rate of about sixteen feet per year. Marsh says:

"It is not known historically when the dunes began to drift, but if we suppose their motion to have always been the same as at present they would have passed over the space between the sea-coast and their present eastern border and covered the area of 250.000 square miles in fourteen hundred years."

EXTENT AND WORK OF MOVING DUNES.

From written records it is known that these dunes have buried extensive forests, fields and villages; changed the course of rivers, and the lighter portions of the sand carried from these dunes by the winds, even while not in sufficient quantities to form sand hills have turned lands formerly fertile into sterile stretches. Along the coast of Jutland in Denmark, the dunes, in the course of two or three centuries, have moved several miles inland covering forests and villages. In our country the drifting dunes have done immense damage upon Cape Cod, in the southern half of Long Island, on the coast of New Jersey and along the Pacific coast from the mouth of the Columbia river southward to Golden Gate Park in California. Small but active areas of dunes along the eastern shore of Lake Michigan and along the valley of the Columbia river in Washington and Oregon have also caused much damage by covering railroad tracks and encroaching upon fields and cities. Along the Snake river division of the Oregon Railway & Navigation Company's line, as much as from $5.000 to $8.000 per year has been spent in keeping the tracks free from sand. At Riparia on the above division large railroad shops and other buildings were moved away to prevent their covering by rapidly moving dunes. The Pere Marquette Railroad which skirts the southeastern shore of Lake Michigan, has spent considerable money in keeping their tracks free from encroaching sand. There have been several railroad wrecks in the country, of more or less importance, as a result of sand being blown over tracks during severe storms. A wreck near The Dalles, Oregon some six years ago caused considerable loss of life and property. Injury to forts along the Atlantic coast from moving dunes has caused the War Department to call upon the Scientific Bureaus of the government to aid them in keeping back these dunes from the immediate location of the forts.

ORIGIN OF INLAND SANDS.

The sand plains which lie in the interior portions of the different continents are either derived from the drifting of dunes or are deposited by floods or are sea-beds uplifted by geological upheaval. The inland sands are generally looser, dryer and more inclined to drift than those of the sea-coast where the moisture and atmosphere of the ocean keeps them always more or less damp and cohesive. After a thorough study of the sand dune region of eastern Washington and the Columbia Valley, it was found that the origin of this sand was an old inland lake or sea-bottom known geologically as Lake Lewis and Clark which covered portions of eastern Washington and Oregon and was perhaps a continuation of old Lake Bonneville. The Columbia river flows through a portion of this old lake bottom, and during the annual period of high water, which occurs in June, large quantities of the sands of this bottom are carried into the river and deposited on flats all along the Columbia as far down as the mouth of the Williamette river. The sand plains in the Lake States and in Kansas and Nebraska are the result of the gradual upheaval of old lake or inland sea bottoms.

SAND AREAS FORMERLY COVERED WITH VEGETATION.

That these extensive areas of sand plains and coastal dunes have in the more or less remote past been covered with vegetation has been proven by scientific investigation. In accounts of investigation in the Nebraska sand hills Doctor Bessey states that at one time these hills were partially if not entirely covered with forest growth, and gives evidence to prove his statements. Doctor Dwight, an early president of Yale College, who traveled extensively through New England in 1800, states that his investigations of the sands of Cape Cod led him to believe that they were formerly almost completely covered by natural vegetation. French scientists state that the millicn and a half acres of land of the sand plains in southwestern France were formerly covered by a dense forest.

The unfertile and waste conditions of these sand dunes and plains today is due to many different influences and conditions. Annual fires, started either through natural causes or by man have had much to do with their present conditions. In a large measure the thoughtlessness and selfishness of man in destroying the forests has brought about the dune formations and these tremendous areas of sand-wastes are constantly on the increase. The fact that these dunes and plains have been covered with a forest growth and are in parts now so covered, gives us strong evidence that the problem of holding the drifting sands and plantingthem with forest trees can be solved though it take years of patient labor and considerable expense.

EARLY EFFORTS AT HOLDING OF DUNES BY PLANTING OF GRASS AND TREES.

Running back for centuries we find accounts of attempts to hold drifting dunes to prevent the destruction of fertile lands back of them. In Egypt before the Christian era the Pharaohs built great walls along the edge of the plains on either side of the valley to prevent the sand from

blowing down upon the fertile fields and orchards along the Nile. The Dutch people since European history began have planted and cared for the dunes along their coast and influenced the formation of others because these dunes keep back the sea from their homes and fields. The first authentic accounts of successful holding of dunes is that of the work on the southwest coast of France, back of which lie extensive sand plains called the Landes. As early as 1778 the French government sent an engineer, Baron de Villers, to the dune region of Gascony to study the conditions and prepare plans for the work of reclamation. The system which he proposed and partially put into execution is, with a few alterations, the same as that in use in most European countries today, and the same that we will probably use when extensive work begins in this country. In justice to Denmark, let us say that under the guidance of its engineer Reventlof, the government began successful work upon the dunes at about the same time as in France, and rather peculiarly about the same system was adopted. The fact that climatic conditions are much more favorable in France than in the countries to the northward has made the final success of dune planting there much more evident. The system proposed by de Villers and later perfected by engineers Chambrelent and Bremontier was the formation of a littoral or protective dune just above high water mark; the planting of this with sand binding grass and a final planting among the grass of seed of the maratime and other pines.

As soon as the protective dune is formed naturally or artificially the planting of beach or marram grass (Ammophlia arenaria) or other valuable grasses is begun. The method of planting is very simple and with good management and careful supervision the formation of the dune is kept under perfect control. The beach grass grows vigorously, putting out fresh rootlets at the nodes as these become covered, thus holding the sand as effectively as a brush fence or palisade. The grass is put out in tufts of four or five plants each at a distance apart dependent upon teh rapidity of sand accumulation. Care and attention in preserving this density, and immediately repairing any damage is all that is requisite in the preliminary holding of the dune.

PLANTING OF TREES NECESSARY FOR THE RECLAMATION OF DUNES.

After the formation of the protective dune comes the work of planting trees in its lee. In Europe the usual method in planting the dune to trees is to cover the surface of the same with brush arranged like slates on a roof and held down by throwing on a shovel full of sand here and there. The seeds of maratime and other pines are then sown with seeds of hardy shrubs like the cytissus, which shade the young pines for the first few years of their growth. As has been shown the planting of grass or other herbs is absolutely necessary for the tentative holding of the moving sand, but every student of the question finds that forest trees must be planted to bring about final reclamation. In the Report of the Harbor and Land Commissioners of Massachusetts for 1896, the chairman of the commission who made thorough investigation of the Province Lands, says:

"It is obvious that the work of planting with beach grass must be first, and that this must be followed up by planting shrubs and trees of rapid growth, interspersed with those of slow growth before the labor of planting shall be completed."

Mr. A. S. Hitchcock of the Division of Agrostology in bulletin 57 of the Bureau of Plant Industry, entitled "Methods used for Controling and Reclaiming Sand Dunes", writes:

"The reclamation is most permanent when the dunes are covered with forest; hence forestation is the ultimate aim wherever possible."

The director of the Central Experiment Station at Ottawa, Canada, was sent abroad in 1901 by the home government to investigate dune planting for the purpose of planting and reclaiming the shifting sands of Sable Island off the eastern coast of Canada. After making thorough investigations in France, Holland and Denmark, he reports that trees must be used if permanent results are to be obtained.

Mr. John Gifford, in writing of the dune region of France, says in part:

"By the formation of these dunes in Gascony 1,625,000 acres of land were made productive and today this region is a health resort. They have demonstrated fully that there is no better way of fixing shifting sands or reclaiming sweeps and removing pestilence than by forest planting."

The methods of planting and reclaiming used in Gascony are practically the same as those used all over Europe and in northern and southern Africa. While conditions and circumstances in the United States are very different, yet the general problem is the same and the work in Europe forms a splendid basis upon which to outline the work here. Their long list of successes cannot be other than an incentive for the commencement and successful completion of the holding and planting of sand dunes along our coasts and rivers and the reclamation of the immense tracts of sand hills, sand barrens and sand plains, which constitute parts of a number of our states.

DUNE RECLAMATION IN THE UNITED STATES.

The work of planting and holding dunes and sand wastes in our country has been very limited and is still in the experimental stage. At Cape Cod as early as 1826-38 planting of beach grass was made by the government and the town of Provincetown at a cost of $28,000. Constant care was not given this planting and the poorer class of fishermen and laborers cu the sod and removed woody growth until the dune lands reverted to their original conditions. Only now with renewed efforts is the work beginning to be successful. Along the coast of Long Island and New Jersey a few scattered attempts have been made to hold the dunes, but nothing of importance has been accomplished. A little planting of grass has been done at the mouth of the Kalamazoo river, but the work was not continued and now conditions are even worse than they were before this work was started. Perhaps the

most successful work has been done in Golden Gate Park at San Francisco. Here the dunes were extensive and were gradually moving towards the city. Experiments were made with planting barley and some of the lupines, but success only came when the beach grass was introduced. A large number of trees have been planted and the most satisfactory are the Monterey pine and the Monterey cypress, which are native to that immediate region, and several species of eucalyptus and the Austrian wattles (Acacia latifolia and A. laphantha).

THE FUTURE IN DUNE RECLAMATION.

Wherever the dunes exist in this country there are numerous native grasses and other herbs which are well suited to preliminary planting, and there are also numerous conifers and a few broad leaf trees which have a high value for the reclaiming of the dunes. Investigations seem to show that such conifers as the white pine, jack pine, loblolly pine, Norway spruce and Austrian pine where not subjected to severe salt winds are adapted for planting on dunes and sand plains of the eastern states. Through the Pacific and Columbia river country such conifers as the bull pine, sand pine, Monterey pine and Monterey cypress are valuable for planting.

On inland sandy lands such as the sand hills of Nebraska, the experimental planting of forest trees has been much more extensive and satisfactory, and the Forest Service is convinced that a very large per cent of the so-called absolute waste lands of the west can be reclaimed and made to grow forests of coniferous trees. The work will require the expenditure of considerable sums of money and years of patient, persistent work, yet the outcome cannot be other than success and that a financial one. The same and worse problems and difficulties have been met and solved by European foresters. We can profit to a certain extent by their experience and accomplish what they have accomplished in a much shorter time.

The great need at present in this sand dune work is a definite knowledge of the dunes as they exist in this country. We must have more accurate knowledge of the origin of the sand which is forming a certain group of dunes, of the processes by which the dunes are being formed, of the amount of plant food which the sand contains, of the moisture in the sand and its source, and lastly and of most importance, of the flora of the dunes the herbs the shrubs and the trees, so that we may judge as to what grasses and trees can be most successfully planted. From this knowledge it will be comparatively easy to plan as to where the sand shall be held, whether in the form of a protective dune or at the place of its origin, and what methods of work will be most practical.

A STUDY OF A PORTION OF THE IOWAN DRIFT BORDER IN FAYETTE COUNTY, IOWA.

BY GRANT E. FINCH.

When a boy, living on the border between the Iowan and the Loess-Kansan drift sheets, the great difference between the two regions was very apparent to me then, and now, in the light of the extensive and interesting contributions to glacial geology in recent years, it is a pleasure to take a geological review of the scenes of my boyhood. It is my purpose to make a few observations relating to the Iowan drift border in Fayette county, Iowa, in particular the region between West Union and Fayette.

The first and most apparent feature to the eye is the great and abrupt contrast in topography; the Iowan prairies, gently undulating, with broad and basin-like valleys, and abounding in boulder-bearing sloughs, the rolling Loess-Kansas region, a timber country so far as not yet cleared, with sharply-rounded hills, deep and often narrow valleys, and almost without sloughs or boulders. Leaving West Union by the east wagon road to Fayette, which crosses the railroad tracks just east of the round houses of the railroad companies, one can locate to the east the Iowan drift border all along the way, almost without leaving the main road. The Loess-Kansan hills rise abruptly and with little transition interval to separate them from regions of typical Iowan in topography, and can be easily seen and recognized a mile or more away. Were we to stand on the edge of the Loess-Kansan hills and look out across the Iowan drift the change would be no less conspicious.

One of the very apparent features of the Iowan drift, as its edge is approached, is its sandy character. The wagon road just mentioned between West Union and Fayette is so sandy as to be poorly adapted for travel, especially to the cyclist or automobilist. This sandy zone is evidence of an outwash from the melting front of the Iowan ice. The farms of this region have a soil that is warm and quick but rather light. They were the first lands to be settled after the occupation of the river bottoms.

Where this sandy zone comes in contact with the edge of the Loess-Kansan there was no overlapping observed; either of the loess over the Iowan deposits or of the Iowan over the loess, a fact that would go to show simultaneous deposition of the two formations.

Another interesting point for observation here is the undrained portion of the Iowan, known as "sloughs". Any one who has lived in this region and dug post-holes, and plowed, knows that the higher ground contains fewer boulders than the sloughs, which are always plentifully dotted with "nigger-heads", usually lying well up out of the ground. The slough soil is a tough, unassorted till. The up-lands are more sandy

and gravelly, and in many places show some signs of assortment of material approaching stratification. Gravel banks and sand banks, well stratified, are shown at the top of all the higher hills in the drift. The crests of the conical hills are crowned with caps of small boulders and cobble stones, so thick-set as to make cultivation impossible. Such hills are well shown at the southeast corner of the Fayette County Poor Farm, the cemetery being located on the top of the highest one. These facts seem to establish a kame—or esker—like nature of the hills and ridges of the Iowan border. It is probable that the present elevations in the drift surface mark the positions of depressions in an ice sheet of irregular surface as it began to melt. The lowest points of these depressions received the materials from the melting slopes. All materials were washed along except the largest boulders, and somewhat assorted by water. Steep kettle-hole depressions in the ice account for the formation of the conical hills, with their caps of cobble stones. Long, gravelly ridges mark the position of longer depressions with more gentle slopes. When the melting had progressed so far that the divides between the depressions in the ice had sunk as low or lower than the original depressions, the remaining fragments of the ice sheets slowly melted in place, depositing the remainder of their detritus without washing or assortment, and the accumulated boulders of the earlier stages of melting were left lying on the surface of this till.

Perhaps the most interesting point to the observer in this region is the three phases exhibited in the valley of each stream that begins in the Iowan drift and flows outward across the border into the Loess-Kansan.

The first phase, that in the Iowan, is a valley broad and shallow, often nearly as wide as long. The contour exhibits no sharp lines. The low, convex divides, with gentle undulations, separate the streams, which course gently through broadly concave sloughs in which they have done very little work since the close of the Iowan ice period.

The second phase of each valley begins where the wide slough bottom narrows down to a point from which the stream flows through a small V-shaped gorge trenched into limestone. This stage of each valley is narrow with rather steep, but smooth and rounded, sides of limestone which stand out clean and unweathered. The narrow floor of each valley is in places covered with a thin layer of till, as is well shown just above the county bridge four and one-half miles south of West Union. Also along the line of the Chicago, Milwaukee & St. Paul Railroad, just above where it intersects an unfinished railway grade two and a half miles east of Randalia, the drift for a distance of a half mile has almost obliterated the valley of the stream. But even here low hills of limestone are exposed to the east of the stream. In general these valleys are sharply defined and little affected by drift deposits. A broad belt of sandy soil, flanking at either side this stage of the valleys, is a constant feature. It stretches outward from the top of the inner valley for a distance of a fourth to a half mile or more.

On the hill-tops along the middle stage of the streams we occasionally find places where the sandy borders give place to bare, flat-topped stretches where the bed-rock lies everywhere practically at the surface. An example of this may be found to the south of the rock cut of the railroad company at Fayette; another occurs on the hill-tops back of the large spring one-half mile north of Fayette; another, one-half mile to the northeast of the small cemetery on the West Union & Fayette road; and still another, one-half mile to the west of the cemetery at Dunham's Grove, in Center township.

There is no disintegrated limestone at the surface of these miniature plateaus, only the hard level surface scantily covered with soil. Occasionally small boulders may be found but they are by no means abundant. Neither can glacial scorings be found, though the absence of rock waste would seem to be evidence of glacial action. It is unlikely that the Kansan drift sheet could have planed off such surfaces, because we could not suppose that the fresh, unweathered Devonian limestone dated back to the same time as the highly oxidized and even decayed Kansan drift. We are then left to believe that such action was caused by the Iowan ice sheet, even though Iowan till and boulders are almost entirely absent.

This second phase of the valleys is interesting as indicating that the glacier along its margin was deeply indented by the streams of the region. The length of the notches back into the Iowan drift varies in six good instances, found between West Union and Fayette, from a half mile in the case of the little streams three to four miles north of Fayette to two miles in the case of the Coulee, a stream southeast of Donnan Junction, and at least six miles in the Volga Valley, or from a short distance above Fayette all the way to Maynard. To that extent were the streams able to keep their channels intact in spite of the Iowan ice sheet. The length of the second phase of each valley varies in proportion to the size of the stream.

The third phase of these valleys begins where the sandy border lands give place to the higher and much more uneven Loess-Kansan. The valleys here are much deeper than in the second stage, but this is due more to the loess accumulations on the hill-tops than to deeper trenching of the streams into the limestone. McGee has well described the paradoxical appearance of the streams rising in the low-lying Iowan plains and flowing into the higher loess-mantled region, and this fact is everywhere well shown in this section.

It seems very strange and unaccountable that in the second and third stages of these valleys as above described, there should be no gravel trains or terraces, but such is the fact. The only exception observed is along the Volga from Maynard northward for some two and a half miles. There we find the valley pretty continuously lined with gravel deposits, but from here on for some five miles in a limestone channel through the Iowan drift, down to Fayette in the Loess-Kansan stage of the valley, no gravel trains or terraces were observed. The sandy outwash from the Iowan is so general just at the margin of the Loess-Kansan hills, and

the sandy borders so prevalent in the second stage of the stream valleys, both signifying extensive water action, that we would expect the streams to have been greatly overloaded with detritus, which would then naturally be deposited in extensive terraces and valley trains.*

It would seem plain that the melting of the ice sheet must have been very slow or else the streams would have been greatly swollen in size and have left extensive deposits high up along the sides of their valleys. The outwash plains of sand and the hills and ridges partaking of the nature of kames and eskers, might be formed without a great flow of water at any one time.

The relations of the Iowan and Kansan drift sheets along their contact line are intricate and puzzling. One finds Kansan-like contours of hills and valleys, dotted with Iowan borders, or again on Iowan topography exposures of materials are apparently Kansan in the gravel beds and roadside sections. A considerable section, beginning one mile south of West Union on the east road to Fayette, appears like Kansan in topography, but has no mantle of loess. It might be expected at the Iowan border, where the deposit of that ice sheet thins out, that there would be frequent outcroppings of the Kansan. Where the deposit seems to be a mixture of the Iowan and Kansan, it may be believed that the Kansan deposits were worked over and somewhat intermingled with Iowa drift during the Iowan ice invasion.

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*A. G. Wilson, in an article a few years ago, suggested the interesting hypothesis, to account for the preservation of such valleys, that the waters successively overflowing and freezing, gradually filled full with solid ice up to the top of the hills, thus protecting the valleys from glacial action.

MUTUAL INDUCTION AND THE INTERNAL RESISTANCE OF A VOLTAIC CELL.

BY L. BEGEMAN.

The usual method of making a rapid determination of the internal resistance of a voltiac cell, primary or secondary, is by means of the condenser in circuit with a ballistic galvanometer. The deflection of the galvanometer due to the discharge of the condenser is first taken on open circuit with the cell and again when the cell is on a closed circuit the known resistance. The working formula is $r = d - d^1$ over $d^1 \times R$, in which d and d^1 are the different deflections of the galvanometer needle and R is the external resistance of the closed circuit. The explanation of this method can be found in Carhart and Patterson's Electrical Measurements. Not having a good standard condenser it occurred to me some time ago while working with a number of students in electrical measurements that an induction coil might be substituted for a condenser in such determinations. The idea appealed to me particularly as I thought that such a method might indirectly bring the student to a definite, elementary understanding of the terms self induction and mutual induction. Every one who has ever attempted to teach these conceptions to a class of students in secondary work, possessing as they usually do an inadequate mathematical training, must realize the difficulty of the task. And yet in view of the general commercial use of periodic currents at the present time, it becomes quite necessary to pay some attention to these phenomena in a practical way.

The diagrammatic sketch below, Figure 1, represents the arrangement of the apparatus for the determination of the internal resistance of a primary or secondary cell by means of an induction coil. In my work I used a small induction coil like that found in the ordinary telephone transmitter.

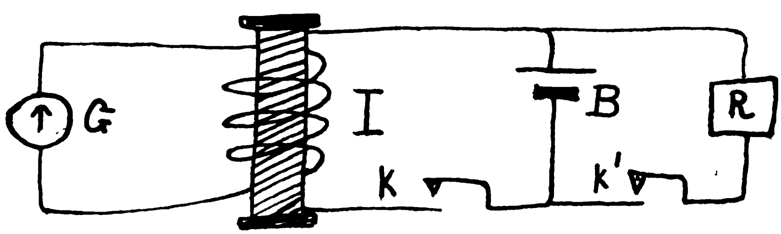
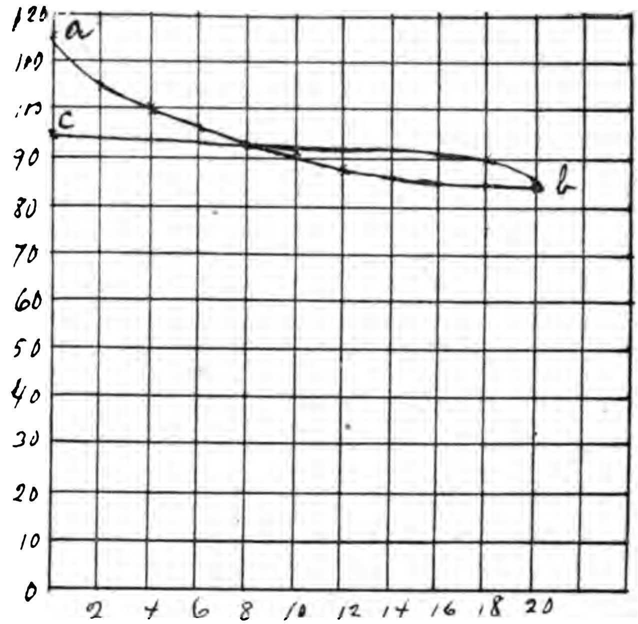


Fig. 1.

The mutual induction of the coil under the action of a current of one tenth of an ampere was approximately 30 millihenrys. In the diagram I is the induction coil, G is the galvanometer in the secondary circuit. The galvanometer should be ballistic although type H D'arsonval made by Leeds, Northrup & Co. gave very good results. The primary circuit contains a resistance box R, a battery B and a key K^1; preferably a knife



MINUTES.
Fig. 2. Curve of Sampson Cell.

switch. The shunt circuit contains a resistance box R, and a key K^1. The operation consists, first, in closing the key K a moment and reading the deflection of the galvanometer. Then a second reading is obtained by closing the keys K and K^1 in quick succession and in the order named.

The demonstration of the working formula depends on the principle that the deflection of the galvanometer is directly proportional to the maximum current in the primary. This is evident since the quantity of electricity which passes through the galvanometer is equal to MC over R^2 in which M stands for the co-efficient of mutual induction, C for the current in the primary, R^2 for the resistance in the secondary. To simplify the demonstration let R^1, the resistance in the shunt circuit, be an aliquot part of R, the resistance in the primary. Applying Ohm's law and the principle of the divided circuit we get the following proportion:

$$d : d^1 :: \frac{1}{r+R} : \frac{1}{(n+1)\,r+R}$$

$$\text{Solving,} \quad r = \frac{R\,(d-d^1)}{(n+1)d^1-d}$$

In the above formula r stands for the internal resistance of the cell, R for the external resistance of the primary circuit, d and d^1 for the two different deflections of the galvanometer and n denotes what aliquot part the shunt resistance is of the primary resistance.

The method of the induction coil gives excellent results when used to obtain the polarization and recovery curves of a voltaic cell. In such a determination the primary circuit remains closed and the key is elevated at regular intervals to obtain the readings of the galvanometer.

To obtain the recovery curve the operation is reversed after changing the galvanometer connections with a commutator. The curves of an old Samson cell are represented in Figure 2.

In obtaining these curves the cell was placed on a closed circuit with an external resistance of 2.54 ohms including that of the primary coil. The maximum deflection obtained was 116 and represented a voltage of 1.07. The line a b is the polarization curve, and the line e d is the curve of recovery. It will be noticed from the diagram that the recovery of the cell was slight in the time considered, indicating that the depolarizer was exhausted.

The method also provides the data for the determination of M the coefficient of mutual induction of the coil, from the equation MC over R=kd. In this equation k stands for the constant of the galvanometer and d for the deflection. Consult Jackson's Alternating Currents for this method. It is evident also, that, knowing the E. M. F. of any one cell, the method can be used to determine the voltage of any other with approximate accuracy. The method gives good results in determining voltages in cases where the internal resistance is low or negligeble compared to the external resistance of the primary circuit.

The advantages of the use of the induction coil in such work as has been suggested are as follows:

First. The induction coil is inexpensive compared with the cost of a standard condenser.

Second. The range of adjustment is far greater than that of the best subdivided condenser. The resistance in the primary circuit can be adjusted to secure any convenient deflection of the galvanometer.

Third. The deflections of the galvanometer are practically unvaried. The differences in the successive readings are very small. With a condenser the readings may vary considerably, particularly when the instrument is not of the best make. Some condensers seem to have a "soaking in" property which results in a variable charge, if the time of depressing and elevating the key during charge and discharge is not constant.

CYCLONIC DISTRIBUTION OF PRECIPITATION.

BY J. A. UDDEN.

Plate XVII

Several years ago I devised a method for ascertaining statistically the relation of weather conditions to different parts of a cyclone for a certain locality or limited region of territory. Some results obtained by this method seem worth the while recording.

The method followed was: by marking off eight radii in four concentric circles I plotted twenty-five areas in a figure, which could be used to represent definite separate tracts in a circular storm. The lengths of the radii of the circles had the ratios 1:4:7:10, and could be used to represent the same number of hundreds of miles in a cyclone two thousand miles in diameter. The radii was drawn at angles of 45° and were not extended into the inner circle. There were thus three tracts marked off in each octant outside the smallest circle. With this latter representing the central region of a cyclone and the figure so oriented as to allow the four points of the compass to bisect four alternate octans, it was used to delimit twenty-five fixed areas in a cyclone. The construction of the figure will be readily understood from the accompanying diagram (Fig. 1) where each area is designated by number.

My method was then to take a sufficient number of observations on the weather at the desired locality when this lay in each of the twenty-five corresponding tracts in an actual cyclone.

These were then averaged for each tract separately, and percentages of frequency of certain weather conditions were thus obtained for each area, such as frequency of precipitation, of cloudiness and of wind direction. The station selected for the first study was Davenport, Iowa, and the data used were the observations taken at this station at 8 A. M. The location of the low areas was taken from the daily weather maps, each corresponding day, by using a transparent paper with a diagram drawn to the scale of the map. Days, when no low areas appeared within a thousand miles of Davenport, were left out. Nearly a thousand observations were used, taken from as many maps. These were distributed somewhat unevenly in the twenty-five tracts of the diagram, but it is believed the number in each tract was large enough to secure a fairly representative average.

It will be seen that this is nothing but a simple method of averaging weather conditions for different parts of a cyclone at a particular station. The results can be plotted on the diagram as a chart. I have called such a chart a *composite cyclone*. For the morning hour precipitation was found to be most frequent at Davenport when this station lies in the tract numbered eight, which extends from 100 to 400 miles west of the central "low". It was also found unexpectedly high in tract numbered twenty-two, which lies from seven hundred to one thousand miles south of the "low". In a southeast direction precipitation decreased very rapidly from the center of this composite cyclone.

Cyclonic conditions were averaged in a like manner for some other places, representing four other climatic regions in the United States. It was found expedient to make use of data slightly different from those used in the Davenport cyclone. I combined the 8 A. M. observations taken at Amarillo, Dodge City, Wichita, and Oklahoma during the years

1894-1898, obtaining a chart which presumably is characteristic for th cyclonic conditions on the southwest plains. I also combined into lik averages the same observations at Helena, Miles City, Leander and Bois City for 1899; those taken at nine stations in the Upper Mississippi Va ley in 1899; and those taken at Detroit and at Buffalo during the yea 1900-1903.

The percentages of precipitation in the twenty-four cyclonic tracts fo each of the five localities thus averaged are given in the following tabl and the same data are plotted in the accompanying figures (Figs. 2-6).

TABLE.

Showing percentages of precipitation in twenty-four different trac of five composite cyclones in different parts of the United States.

Number of Tract.	Davenport.	Amarillo, Dodge City, Wichita and Oklahoma.	Helena, Miles City, Leander, and Boise City.	Missouri Valley Stations.	Detroit and Buffalo
1	26	3	0	20	44
2	21	14	17	21	40
3	15	20	10	11	40
4	0	—	6	8	40
5	3	5	0	5	26
6	4	3	3	5	15
7	7	9	3	7	15
8	35	5	13	11	26
9	17	21	16	15	33
10	17	21	18	20	25
11	8	19	6	20	18
12	8	13	14	6	17
13	6	2	10	2	18
14	4	2	6	5	5
15	4	8	4	2	0
16	10	6	5	5	34
17	0	21	20	6	25
18	17	18	1	8	9
19	19	6	12	9	8
20	2	6	8	8	9
21	2	6	5	2	6
22	22	6	2	3	—
23	7	7	2	4	0
24	6	7	3	4	1
25	0	6	16	3	0

These tables and charts show clearly: 1. That the area of greatest precipitation is not the same for different stations. They suggest that the cyclonic distribution of precipitation bears a definite relation to climate, and varies with this.

2. That if the area of greatest precipitation is to the southeast of the center of cyclones in the Upper Mississippi Valley (as taken for granted hitherto in general works on American meteorology?) there must be a very marked diurnal shifting of this area concerning which nothing is at yet known; for to make up for the deficiency of precipitation in this part of the composite cyclone of the morning hour there would have to be a corresponding excess during some other part of the day.

3. That, in either case, the variations in the location of this area of greatest precipitation, be they local or diurnal, are quite probably of sufficient magnitude to appreciably affect the accuracy of weather forecasts.

Explanation of Figures.

Plate XVII.

Fig. 1. This figure shows the location of each of the twenty-five tracts as averaged in each cyclonic area. The numbers are those given under the columns "number of tracts" in the preceding tables.

Fig. 2. Distribution of precipitation and wind directions in a composite cyclone, based on the 8 A. M. observations taken at Davenport during the years 1893-1897.

Fig. 3. Distribution of precipitation and wind directions in a composite cyclone, based upon the 8 A. M. observations taken at Amarillo, Dodge City, Wichita and Oklahoma during the years 1894-1898.

Fig. 4. Distribution of precipitation and wind directions in a composite cyclone, based upon the 8 A. M. observations taken at Helena, Miles City, Leander and Boise City in 1899.

Fig. 5. Distribution of precipitation and wind direction in a composite cyclone, based on the 8 A. M. observations taken at all the stations in the Upper Missouri Valley during 1899.

Fig. 6. Distribution of precipitation and wind direction in a composite cyclone, based on the 8 A. M. observations taken at Detroit and Buffalo during the years 1900-1903.

Note: In the figures numbered 2, 3, 4, 5 and 6, the shading represents different percentages of precipitation as follows:

Solid black,	40 per cent. and above.
Crossed parallel lines,	30-39 per cent,
Parallel lines,	20-29 per cent,
Interrupted parallel lines,	10-19 per cent,
No shading, less than	10 per cent,

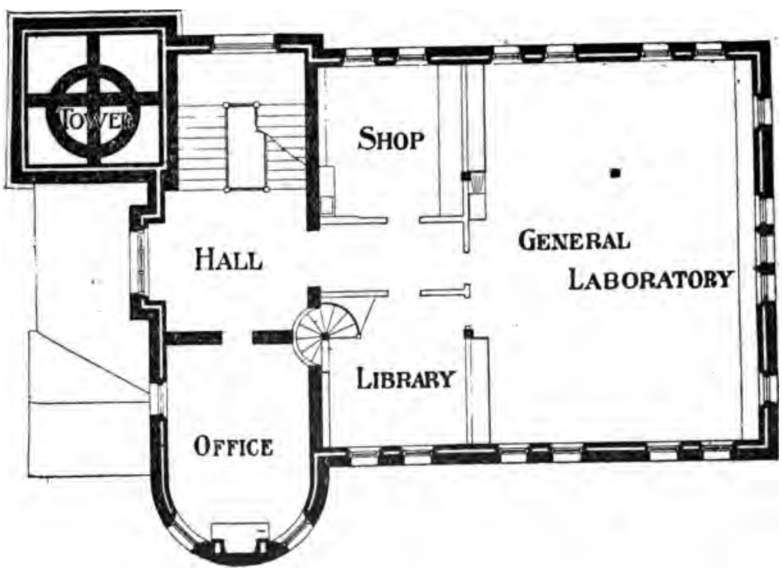
THE PHYSICAL LABORATORY AT IOWA COLLEGE.

BY FRANK F. ALMY.

With the completion of the new library building, the gift of Andrew Carnegie, the old library building, Goodnow Hall, became available for Physics and Mathematics. The building is a very substantial red stone building, finished throughout in hard wood.

The first floor provides two lecture rooms for Mathematics, a room for mechanical drawing, a small room for an apparatus and calculating room and department library, and a very pleasant room for office and consultation room for the department of mathematics.

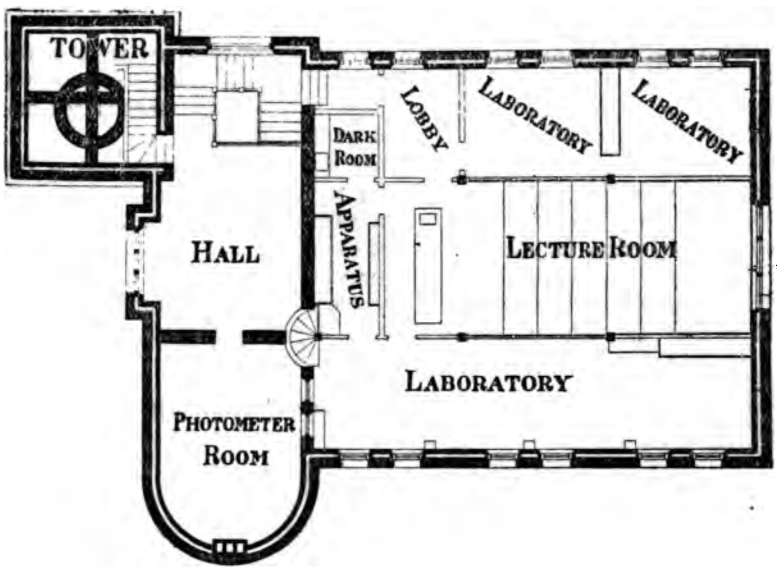
The second floor as remodeled provides the general laboratory for Physics which very comfortably accomodates the laboratory work for the courses of Elementary and General Physics. Directly adjoining the



Second Floor: Physics

general laboratory on one side of the entrance hallway, is the library and weighing room; on the other side is a preparation and repair shop, containing a work bench and tools, a chemical bench and chemicals, the switch-board, a motor and lathe. Firm support for apparatus is obtained in the general laboratory by a cement shelf built upon the wall, extending the entire length of one side of the room. In the weighing room the same result is obtained by a heavy shelf supported upon the wall.

The third floor provides the laboratories for the advanced courses and a very satisfactory lecture room with raised floor. The lecture table and laboratories are fitted with gas, water, direct and alternate current circuits. Immediately back of the lecture table is an apparatus room for the storage of all demonstration apparatus; adjoining this a photographic dark-room. The department office is on the second floor and above it a



Third Floor; Physics

dark-room which will be fitted for photometric work. The short circular stairway gives direct communication between the two floors.

Notwithstanding the fact that the building was originally designed for other use we find it remodels into a satisfactory and very conveniently arranged physical laboratory.

A SIMPLE DEMONSTRATION OF THE DOPPLER EFFECT IN SOUND.

BY FRANK F. ALMY.

The example which is perhaps most frequently cited as an illustration of the Doppler effect is the change of pitch of a locomotive bell or whistle or of a street-car gong in rapid motion, particularly as heard by a person on board a car passing rapidly in the opposite direction on a parallel track. To the use of this illustration Professor R. W. Wood[1] objects on the ground that "scarcely one person in ten has any distinct recollection of having noticed the phenomena unless his attention has been directed to it".

Professor Wood proposes to attach a pitch pipe to the tip of a hollow bamboo rod and a rubber hose to the hand end of the rod so that by this means the pipe may be sounded and waved to and fro in the "line-of-sight". This simple device may be effective if blown by compressed air, but complications are introduced if the demonstrator attempts to blow the pipe while he waves the rod.

While considering the experiment as suggested by Professor Wood, it occurred to my assistant, Mr. H. D. Way, that the motion in the "line-of-sight" could be produced by attaching the pitch pipe to the arm of the rotating apparatus. The additional suggestion immediately occurred that the reed could be placed at the base of a funnel faced in the direction of rotation and be made to sound by the air pressure caused by the rotation. Following out these suggestions we produced a simple device which very effectively demonstrates the Doppler effect. The tone has its highest pitch when moving directly toward the observer, slurs continuously through its natural pitch as it moves across the "line-of-sight" to the lowest pitch when moving directly away from the observer.

[1] Phys. Rev. 4; 504.

THE EFFECTS OF PRESSURE UPON LINES IN THE SPECTRUM OF IRON.

BY FRANK F. ALMY.

Humphreys and Mohler[1], in 1896-7, made an extended study of the effect of pressure upon the wave frequencies of the lines of the emission spectra of a larger number of the metalic elements. The source used was an enclosed electric arc about which the air pressure could be varied, the pressure being carried up to fourteen atmospheres. The results of their experiments indicate that all isolated lines shift toward the red end of the spectrum with increased pressure, the shift being proportioned to the wave length for lines of a given series, but the factor of proportionality being different for lines of different series.

In the winter of 1901-2 at the suggestion of Professor Michelson, I undertook the measurement of the pressure shift of some of the lines of the spectrum of iron by a method quite similar to that employed by Humphreys and Mohler, but with essential differences. The source of light employed was a self induction spark produced by rotating a sprocket-wheel by a steel spring. The spark gap was contained within a cast brass vessel with properly packed shaft for driving the sprocket wheel and insulated leads, and a plate glass window. An image of the spark was formed upon the slit of a grating spectrometer. The spectrum was formed by a 5-inch Rowland concave grating of 21 feet radius ruled 20,000 lines to the inch. My study was confined to the second order spectrum in which the dispersion was such that 1 Angstrom unit was approximately 1 mm. in the spectrum; and to that part of the spectrum of iron lying between wave lengths 4014 and 4528. The photographs were made by the ordinary method of three exposures to check any accidental displacement of the plate.

The pressure shifts found for the lines in this region conformed very closely to those published by Humphreys. Of the iron lines in this region certain of the broader, denser lines are reversed at their centers in the spectra under pressure. This is particularly evident in the lines 4045, 4063, 4071, 4271, 4308, 4325, 4383 and 4404. It may be noted that these reversals agree with those noted by Professor Hale[2] when the spark gap was under pressure in a liquid, and later observed by Hale and Kent[3].

After a somewhat extended study of this region of the spectrum of iron by means of the grating spectrometer, I attempted to apply the echelon spectrometer to the problem of pressure shift.

The same source was employed as before, the light first passing through a prism spectrometer using two 60° carbon bisulphide prisms in succession, which gave sufficient dispersion so that lines separated by 1

Angstrom unit could be placed separately upon the slit of the echelon spectrometer. To facilitate the arrangement and manipulation of the apparatus a plane mirror was introduced between the colimator and the prisms, which permitted of rotation so that any line of the prism spectrum could be placed upon the slit of the echelon spectrometer. The echelon consisted of 30 plates, 5 mm. thick and 1 mm. width of step. This would make the order of spectrum employed of the order of 5000, which would make the dispersion several times that of the grating spectrometer previously employed. The eye piece of the echelon spectrometer was fitted with a plate holder, for photographic work.

Considerable work has been done by eye observation and some 200 negatives were taken of the most interesting lines of the iron spectrum but as bearing upon the pressure shift they only contribute evidence confirming the unsymmetrical broadening toward the red.

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1 Ap. Jour. 6; 169; 1897.
2 Ap. Jour. 15; 132; 1902.
3 Ap. Jour. 17; 154; 1903.

ELECTRICAL STANDARDS.

BY KARL E. GUTHE.

As soon as any commodity becomes of commercial value a system of practical units has to be established for its measurement. In the case of electrical energy we have fortunately been saved from the natural development of a system of units, a development which has, for example, given us our remarkably complex, incongruous, and unscientific collection of weights and measures. While by no means perfect the electrical units have at least the advantage of being consistent, and being worked out by scientists they have naturally been based upon the metric system. I do not wish to tire you with a lengthy description of the various methods which have been employed for the derivation of the different electrical, or to be more specific, electro-magnetic units, in terms of the fundamental units, the centimeter, gram, and second,—suffice it to state that of the three most important electrical units two, that of the resistance, the Ohm, and that of current, the Ampere, can be determined by so-called absolute methods, in which determinations only length, mass and time enter into the measurements, while the third, the unit of electromotive force, the Volt, is found from the other two by the use of Ohm's law.

All other electrical quantities can easily be derived from these three by the application of well-known mathematical relations.

As can be imagined determinations of the absolute or c. g. s. units are difficult and require a great deal of labor and time; so it is natural that an attempt was made to substitute for these theoretical units practical and wherever possible, concrete and easily reproducible units, standing in definite relation to the former. This is not difficult in the case of the unit of resistance, the Ohm. A column of mercury of definite mass and length at a specified temperature will always have the same electrical resistance to a constant current and by a series of classical experiments* it was determined some years ago that the Ohm which equals 10^9 c. g. s. units of resistance is represented with sufficient accuracy by the resistance, at the temperature of melting ice, of a column of mercury, 14.4521 grammes in mass, of a constant cross sectional area and of the length of 106.3 centimeters.

At the International Electrical Congress at Chicago, in 1893, this unit was adopted and thus replaced some of the older measures which did not as closely correspond to the theoretical value. For a perfectly satisfactory definition of the mercury ohm, it is, however, necessary to add to the already given data the method of filling the tube, the form of the

*Dorn, Zeit. f. Instr.—Kunde, 1893, APP.

end vessels, the manner in which the current is led to the mercury column and the factor to be used for the calculation of the end correction. Under such conditions it is possible to reproduce mercury ohms with an accuracy of 1 in 50,000, i. e., an accuracy far surpassing that with which the ohm can be determined in absolute measure.

With the ampere and the volt the case is different. We cannot construct a standard of current but must make use of one of the effects of a current for its measurement. The best and most reliable method seems to be, to measure a current by means of the electrolysis of a silver nitrate solution, the silver to be deposited upon a planinum bowl. The Chicago definition of the ampere states that a constant current of one ampere will deposit in a voltameter or coulometer, as I shall in the following always call this instrument, 1.118 milligrams of silver in one second.

While we cannot construct a cell whose electromotive force is exactly one volt, there are standard cells which have a definite and constant electromotive force if properly constructed. In 1893 only one of these was known, the Clark Standard Cell, and it was selected as a practical standard, its electromotive force being assumed at that time to be 1.434 volts.

Here we have then the definitions of the three fundamental electrical units and they were recommended by the international congress for adoption by the Governments represented. In the United States, Great Britain, Canada, Germany, Austria and France government action was taken, but in some important points these legal definitions are not quite in accordance with those adopted in Chicago.*

It is apparent that it is not necessary to define all three units, but the third can always, by Ohm's law, be derived from the other two. The United States legalized all three, a procedure which was bound to lead to trouble if it should be found that one or two of them should be incorrect, because it is hardly to be expected that Mother Nature will change Ohm's law in spite of all congressional decisions. The first work which seemed to indicate that the value of the volt was incorrect was an investigation at the Reichsanstalt* in Germany; and at practically the same time two researches carried out at the University of Michigan fully confirmed the results obtained, and also proved that the electro-chemical equivalent of silver depends greatly upon the specifications of the silver coulometer.* Soon other scientists took up the subject and the above mentioned results have received confirmation. Prominent among the investigators of the silver coulometer is Professor Richards* of Harvard, who designed an apparatus which we may call a porous cup coulometer, for which he claimed a higher degree of accuracy than could be obtained by the usual form. I made an extended research* comparing the various forms which had been used by the different experimenters on the subject and found Richards' claim to be correct, and designed a form of

*Wolff, Bulletin, Bureau of Standards, I, p. 39, 1904.
*Kahle, Zeit. f. Instr. K. 18, pp. 229 and 267, 1898.
*Patterson and Guthe, Phys. Rev. 7, p. 257, 1898.
Carhart and Guthe, Phys. Rev. 9, p. 288, 1899.
*Richards, Collins, and Heimrod, Proc. Am. Ac. 35, 123, 1899.
Richards and Heimrod, Ibid. 37, p. 415, 1902.
*Guthe, Phys. Rev. 19, p. 138, 1904.

porous cup coulometer which is somewhat more convenient for use than Richards' type. The main disturbing factor in silver coulometric work lies in the formation around the silver anode of a complex silver salt which on reaching the platinum cathode deposits too much silver. The introduction of a porous cup keeps the troublesome solution at least partly away from the cathode, if the current is not allowed to be closed for more than an hour. I use in my form a platinum bowl of the size recommended by the Chicago congress and a closely grained porous cup only a little smaller in diameter. At the bottom of this cup some granulated silver is placed and upon this a large plate of silver, forming the anode, is pressed. The granulated silver partly decomposes the heavy solution streaming from the plate and makes the use of a siphon (to keep the solution inside the porous cup at a lower level than the outside) unnecessary.*

Richards' and my results were corroborated by Van Dijk, namely that with a porous cup coulometer the silver deposit is about 3 in 10,000 smaller than in the usual form, and that such coulometers will give results which can be relied upon to 1 in 10,000.

While thus the silver coulometer was improved other investigators attacked the problem of perfecting the standard cell. The Weston standard cell with solid hydrated Cadmium sulphate has proved to be, in many respects, so far superior to the Clark cell that doubtless it will at the next international congress be selected as the standard cell and it is natural that the most recent work has been done with this type of cell instead of the Clark. Carhart, Hulett and Wolff* have by their researches upon the electrolytic preparation of Hg_2SO_4 enabled us to construct cells which, when made by different experimenters, will closely agree in their electromotive force. According to Hulett the Hg_2SO_4 should be prepared electrolytically from an acid solution of concentration larger than normal, so as to avoid hydrolysis.

By these researches we have now arrived at a point where we can rely with equal confidence upon as well the indications of the silver-coulometer as upon an accurate reproduction of Standard cells, and the next question of importance was to redetermine with improved apparatus the absolute values of the electrochemical equivalent as determined by the porous coulometer, and the electromotive force of the improved standard cells. I have just finished this work, the experimental part of which was done at the Bureau of Standards in Washington. The apparatus which I used was a large electrodynamometer, consisting of two coils, each of a single layer of wire. This allows an accurate measurement of the linear dimensions entering into the calculations. The large coil was wound upon a plaster of Paris cylinder while the smaller movable coil was wound upon Berlin porcelain. Two movable coils of different dimensions were used, and the small difference of the two final results served as a valuable check upon the whole work. The torsional

*Guthe, Bull. Bur. Standards, I, p. 349, 1905.
*Van Dijk, Ann. Phys. 19, p. 249, 1906.
*Carhart and Hulett, Proc. Am. Electroch. Soc. 5, p. 59, 1904.
Wolff, Proc. Am. Electroch. Soc. 5, p. 49, 1904.
Hulett, Zeitsch. Phys. Chem., 49, p. 483, 1894. Phys Rev. 22 p 321, 1906.

moment produced by the electromagnetic action between the two coils was balanced by an accurately measured angular twist of the suspending phosphor-bronze wire, i. e., by a torsional moment which may be determined in terms of centimeters, grams, and seconds. To obtain this moment a cylinder of known moment of inertia was vibrated when suspended from the same wire as the movable coil and the period of its torsional vibrations determined.

Let K be the moment of inertia, T the time of vibration of the cylinder, then the torsional moment for unit angle of twist of the suspension is given by the equation,

$$J = \frac{4pi^2K}{T^2}$$

The dimensions of the two coils of the electrodynamometer were so chosen that the field strength inside the stationary could be expressed by the simple equation,

$$H = \frac{4piN}{\sqrt{D^2+L^2}} I = C\,I,$$

where N is the number of turns of wire on the coil, D its diameter, L its length and I the current flowing through it; and the effective area of the movable coil by the equation

$$A = pi\,r^2n,$$

where r is the average radius of the movable coil and n the number of turns. The torsional moment produced by the current I flowing through the electrodynamometer is then, with the coils at right angles to each other $T^1 = ACI^2$; this was balanced by the torsional moment of the suspension when the torsion head was turned 90 degrees, or n over 2 radians. Solving for the current, we obtain as final formula:

$$I = \frac{1}{Tr}\sqrt{\frac{pi\,K\sqrt{D^2+L^2}}{2Nn}}$$

As you see, only measurements of length, mass and time enter into the calculation and this is therefore an absolute determination of the current.

This current was sent through resistance standards and the difference of potential produced compared by means of an accurately calibrated potentiometer with the electromotive force of a dozen standard cells.

The absolute value of the latter is then easily calculated from the current and resistance by means of Ohm's law.

The electrochemical equivalent of silver had been previously determined* by direct comparison between the electromotive force of one of the standard cells and the potential difference at the terminals of the same standard resistances when a constant silver depositing current passed through it.

The standard cells were kindly given to me by Professors Carhart and Hulett. Most of them were set up with electrolytically prepared Hg_2SO_4

It is needless to say that in the actual measurements a great many difficulties were encountered; but thanks to the valuable help of my

*Guthe, Phys. Rev. 19, p. 152, 1904.

colleagues at the Bureau of Standards, and due to the fact that the wonderful facilities of this institution were placed at my disposal, I was able to obtain results, which I consider accurate within 1 in 10,000, an accuracy which I believe has not been obtained before in measurements of this kind.

My final results are the following:

A. Standard cells with electrolytically prepared Hg_2SO_4.

Clark cells at 25° C.

E. M. F. = 1.42040 volts.

Cadmium cells at 25° C.

Acid solution stronger than normal,

(F series) E. M. F. = 1.01827 volts.

Acid solution weaker than normal,

(E, K and O series) E. M. F. = 1.01833 volts.

B. Standard cells with chemically prepared Hg_2SO_4.

Cadmium cells at 25° C. (C series)

E. M. F. = 1.01857 volts.

This shows that the cells with electrolytic Hg_2SO_4 have an electromotive force 0.0003 volt lower than those with chemically prepared Hg_2SO_4

Reducing to 20° C, we obtain for the Cadmium cells,

F. series, E. M. F. = 1.01847 volt.

E, K and O series, E. M. F. = 1.01853 volt.

C series, E. M. F. = 1.01877 volt.

Reducing to 15° C, we obtain for the Clark cells,

E. M. F. = 1.43296 volt.

By this investigation I have therefore fully corroborated the results of our former work, namely that the correct value of the Clark standard cell at 15° C is nearer 1.433 volt and not 1. 434 as legalized in the United States.

The electrochemical equivalent of silver as determined by the porous cup coulometer is 1.11773 milligrams per coulomb.

The following table gives a comparison of the results obtained by former investigations. The values of the electrochemical equivalent are reduced to the porous cup coulometer. The values of the E. M. F. of the Clark cell are given for 15°C, that of the Cadmium cell for 20°C.

A.

ELECTROCHEMICAL EQUIVALENT OF SILVER.

Observer	Date	Coulometer	Method	Found	Corrected
Mascart	1884	Usual type	Current balance	1.1156	1.1153
Fr. and W. Kohlrausch	1884	Usual type	Tangent galvanometer	1.1183	1.1177
Rayleigh and Sidgwick	1884	Usual type	Current balance	1.1179	1.1176
Gray	1886	Plate Coulom'r	Sine galvanometer	1.1183	1.1178
Koepsel	1887	Usual type	Current Balance	1.1174	1.1169
Pellat and Potier	1890	Usual type	Current Balance	1.1192	1.1189
Patterson and Guthe	1898	Sil'r-oxide type	Electro-dynamometer	1.1192	1.1177
Pellat and Leduc	1903	Leduc's type	Current balance	1.1195	1.1190
Van Dijk and Kunst	1904	Usual type	Tangent galvanometer	1.1182	1.1178
Guthe	1905	Porous cup	Electro-dynamometer	1.1177	1.1177

B.

ELECTROMOTIVE FORCE OF STANDARD CELLS.

Clark	1872	Clark at 15 degrees	1.4378
Rayleigh and Sidgwick	1884	Clark	1.4345
Kahle	1896	Clark	1.4322
Carhart and Guthe	1899	Clark	1.4333
Guthe	1905	Clark	1.43296
Guthe	1905	Cadium at 20 degrees	1.01857

Doubtless in the near future other determinations of the absolute value of these important electrical units will be made, some being carried on in the national physical laboratory in England, and some at the Bureau of Standards at the present time. It is to be hoped that in a couple of years steps may be taken for new international action looking towards a uniform legalization of electrical units throughout the civilized world and of units which agree more closely with those derived from absolute measurements. Certainly only two can be defined as fundamental, moreover, even if based upon c. g. s. units they should be concrete units unaffected by the possible discovery of slight errors to be found in future time in the absolute values. It is true they would not be prototypes in the same sense as the international Kilogram and the meter, but there is a certain advantage in the possibility of their reconstructions at any time by different observers. Whether, besides the ohm the ampere or the volt shall be chosen as the second fundamental unit can hardly be predicted at the present time; that depends upon the question which of the two will prove to be reproducible with the highei degree of accuracy. Under otherwise equal conditions preference shoulu be given to the coulometer since the current is found in terms of the fundamental units alone, while in the present determinations of the volt, the ohm enters always as a factor and with it the error made in its measurement, or in other words, the present methods for the determination of the volt are not strictly absolute methods. Whatever decision may be reached it is certain that there will be a closer agreement than under the present law between scientific results and the system used in the commercial world.

STUDIES OF THE COLLEMBOLAN EYE.

BY J. E. GUTHRIE.

Plate XVIII.

In any primitive group of animals, there is an unusual interest attached to any organ which shows a simple structure, as having a possible bearing upon the history of the organ in a more highly specialized condition, as found in higher, closely related groups. Sometimes organs of seemingly simple structure are very puzzling from the fact that we are at a loss to determine whether their condition is primitive, or is due to degradation or partial atrophy. Embryological studies are often of value in determining the case, but not always. In entomology we have surprisingly few embryological studies which are specific enough to guide us in such determinations. When a group of insects varies widely however, in relation to any specified structure, a comparative study of its adult condition in the different members of the group may be of value.

In the minute, wingless insects of the order (or sub-order) Collembola, often included, along with the true Thysanura, under the ordinal name of Thysanura as constituting a lowly branch upon the insectan phylogenic tree, we find no compound eyes, nor do we generally find any isolated ocelli. The ocelli are bunched or gathered together in the post-antennal regions on the right and left eye-spots.

It is not impossible, I think, that each eye-spot may represent all that remains of an ancient compound eye, the few ocelli being modified survivors of some of the component ommatidia. Embryological research must be looked to for the determination of this question if it ever is determined. If this should prove to be true, we must regard the compound eye as having undergone a certain very definite amount of decadence at a period remote enough to antedate the general branching off of species. A modern Thysanuran, *Machilis*, shows many characters that must have been likewise possessed by the ancestor of the Collembola. *Machilis*, moreover, has well-developed compound eyes; so that it seems not unlikely that the Collembolan eye has descended from that type.

The present paper, however, has to do rather with the modifications of the eye from the Collembolan type, than with its possible pre-Collembolan history.

The eyespots are situated dorso-laterally, caudad to the bases of the antennae, as may be seen in Figures 1 to 4. The first two show a typical horizontal-headed species; the following two a species with the head vertical. Each eyespot may contain eight or fewer ocelli, but never more than that number. There are abundant indications that when fewer than eight ocelli are present, the condition denotes atrophy of one or more of the oceller units, for eight seems to be the typical number of ocelli for the Collembolan eye. Some whole genera, it is true, show a

smaller number, but there is reason for believing that their condition is not a primitive one, but one derived from that mentioned above. Thus, in the genus Tomocerus, each eyespot contains but six ocelli. In Sir John Lubbock's great "Monograph of the Thysanura", there appear some errors concerning the ocelli of certain genera of the Collembola; he state that *Isotoma* and *Tomocerus* have each seven ocelli on a side. His figures, however, are at variance with the statement, and show eight for *Isotoma*, which is the usual number in that genus, and but six for *Tomocerus*, which is likewise correct, Figs. 1 and 7. He states that *Orchesella* has six, and with this his figure of the eye in that species agrees. I have examined specimens of four species of *Orchesella*, and all appear to have eight ocelli, though one of these is usually quite small. Fig. 6.

A study of their positions indicates that the individual ocelli are probably homologous in all the different species; and that there is not only a typical number of ocelli, but a typical pattern for the placing of them upon the eyespot. This may vary somewhat, but usually seems to have the ocelli placed along the course of a more or less elongated letter S. Certain of the ocelli in this figure seem to be less tenacious of existence than others, and in certain genera we may find these growing smaller and less important as we pass from species to species until they entirely atrophy and actual numerical diminution results.

The Collembola show a strong tendency to the cave habit, and thus we find more or less profoundly modified species in many of the genera. In many cases, the modifications induced by the cave habit have so differentiated species along common lines, as to have led to the formation of new genera for their reception. It is to be expected that the visual organs would be most quickly and deeply modified by a habit which led to a life in situations where light was obscure or absent.

I have recently re-examined all the species in my collection, as well as all accessible figures of the eyes of species I have not, and find some very interesting gradations. The eyespot containing the ocelli is usually very dark, often deep black. It often gives bronzy reflections when viewed by reflected light, excepting the ocelli themselves which appear dense black. In shape the eyespot varies considerably, according to species. While it is commonly of a more or less elongated rectangular shape, with the longer axis corresponding to that of the animal, it may be oval, ovoid, reniform, triangular or crescentic, and is often irregular upon the edges. The shape corresponds rather closely to the placing of the ocelli; sometimes persisting, however, over areas from which the ocelli have atrophied. When the ocelli disappear from the middle of an eyespot, as they do in some instances, the pigment may also disappear from the middle part of the eyespot and still be retained at its two ends where the ocelli still persist. This gives rise, of course, to the appearance of two eyespots on each side of the head. One of these may even disappear, leaving but one small one on each side. Fig. 5 shows an eyespot which may be considered fairly typical. In this species (*Isotoma muskegis* Guthrie) the ocelli are approximately of the same size, while the densely pigmented eyespot is elongate, and pretty

regularly shaped. For convenience of comparison I have lettered the ocelli in a definite order, like the stars in a constellation. This constellation, as has been stated, shows somewhat of the form of the letter S. The ocelli are lettered in order, beginning with the one most cephalolaterad in position. In looking through a collection of drawings of the ocellar constellations of species scattered throughout the different genera, we find ocellus D to be somewhat variable in position. This might be termed the central ocellus if we had only to deal with species having the eyespots broad. In forms with the narrower eyespot, where ocelli A and E are strung out farther apart, opportunity seems to be offered for D to take position on the lateral edge where I judge that it is the most useful, for reasons to be stated later. Ocellus H is another which is quite variable in position. It oftener shows positional affinity with C than with G, though in some instances it seems to have moved caudad nearer the latter. Now it may be merely a coincidence, but it certainly is true that when there is atrophy among the ocelli, these two are usually the first to decrease in size, and the first to be eventually lost. When D is central in position, as in the members of that group of *Sminthuri* including *Sminthurus minutus* MacG., *S. 4-maculatus* Ryder, *S. aureus* Lubb. and *S. niger* Lubb,, this is notably true, it being always small though not necessarily the only small ocellus of the constellar S. See figure 8. Ocellus H appears to have usually the slightest hold on existence of any, though some exceptions will be noted. In *Sminthurus aureus* Lubb., fig. 8, all the ocelli excepting D and H are of approximately equal size. Ocellus D, which is central in position, is very small; while H is yet smaller and is somewhat triangular in shape, and is situated close to G. In the genus *Papirius*, Fig. 10, is found a condition which shows the fate of the ocellus which becomes crowded toward the center, losing its position upon the margin. *Papirius maculosus* Schött. Fig. 9, shows H of normal size and on the edge of the very convex eyespot. The shortening of the eyespot has apparently crumpled the line, forcing C out of the marginal row. It is small, though not so small as D, which is also nearly central. Some of the species of *Sminthurus* show a condition similar to the *Papirius*, though not usually so well marked. Probably the shortening of the eyespot is to be co-ordained with the shortening of the dorsal surface of the head, due to the vertical instead of horizontal position of the head among the Sminthuridae. The prominent position of the eyespots is heightened by their own great convexity, while the positions of the most useful ocelli being around the edge of the raised area, an outlook is secured in all directions by each eyespot. The insect's demand for a view straight dorsad seems to be so little as to allow central ocelli to atrophy through disuse.

In the genus *Lepidocyrtus*, we find in a typical species, *L. purpureus* Lubb. Fig. 10, a somewhat elongate eyespot. Ocelli D and H are decadent, but still present. In this genus there was once an eyeless species, but it had the honor of being later considered as the type of a new genus *Cyphodeirus*. Two species of *Lepidocyrtus* which I have described from

Minnesota, *L. 10-oculatus* and *L. 6-oculatus*, are interesting in their stages of ocellar atrophy. See figures 11 and 12. In the former the eyespot is shortened and C forced in from the margin as in *Papirius*, fig. 9. This ocellus is small, while the two preceding it are large. D has apparently disappeared, and from the position of the next ocellus, it seems probable that E has also atrophied. Two are found in the caudal end of the eyespot which are probably F and G, if we assume, as we safely may, the atrophy of H. In the closely allied *L. 6-oculatus* the small ocellus C has been lost, also one corresponding to the smaller of the two caudally placed ones in Fig. 11. This leaves for *L. 6-oculatus* only A, B and F, a considerable portion of the eyespot between the first two and the last being destitute of ocelli. This intermediate space, having lost the ocelli, has also lost its pigment; and there remain a cephalic and a caudal spot, containing, respectively, two and one ocelli. In the genus *Isotoma* there is a species, *Isotoma 4-oculata* Tullberg, Fig. 13, with similarly divided eyespots, but in this the cephalic portion contains but one ocellus. Probably, from its positional relation to the postantennal organ, it is ocellus B, and the caudal spot contains F. In Wahlgren's species *Isotoma binoculata*, the small cephalic spot alone is present, and contains the single ocellus. In the blind species *Isotoma fimetaria* (L), there is no evidence of ocelli or even of pigmented areas. In the genus *Sminthurus* we have a blind species in which some specimens possess very little pigment upon the general surface, while others show a considerable amount of fine reddish pigment dots. This species does not possess ocelli, and seldom shows evidence of a pigmented eyespot, but some specimens have been taken in which unmistakable pigmented areas representing eyespots were present. A species very closely related, structually, but with a well-pigmented body, shows a single small ocellus on each side of the head situated on a very small black eyespot. This ocellus is probably either A or B.

There are but a few examples of the peculiar conditions of ocellar atrophy obtaining among this interesting group, but they may be sufficient to call attention to the following conclusions: The number and arrangement of ocelli, subject to various modifications may be recognized throughout the Collembola. Members of this group occupying marginal. positions have greater tenacity of existence than others. Central ocelli are usually the first to go. A more advanced stage of atrophy deprives the whole middle part of the eyespot of ocelli and at the same time or a little later of its pigment. The last part of the eyespot to persist with its ocelli is the most cephalic end. Vestigial pigment may determine the position of an eyespot after all the ocelli have been lost.

EXPLANATION OF PLATE.

Figure 1. Dorsal view of head of *Isotoma leonina* Packard.
2. Lateral " " " " " *sensibilis* Tullberg.
3. Dorsal " " " " *Sminthurus aureus* Lubbock.
4. Lateral " " " " " " "
5. Dorsal view of right eyespot of *Isotoma muskegis* Guthrie.
6. " " " " " " *Orchesella albosa* Guthrie.
7. " " " " " " *Tomocerus niger* Bourlet.
8. " " " " " *Sminthurus aureus* Lubbock.
9. " " " " " " *Papirius maculosus* Schött.
10. " " " " " " *Lepidocyrtus purpureus* Lubbock.
11. Dorsal " " " " " " *10-oculatus* Guth.
12. " " " " " " " *6-oculatus* Guth.
13. Lateral view of head of *Isotoma 4-oculata* Tullberg.

The ocellar S referred to in the text is indicated by the dark stripe connecting the ocelli.

In figures 7, 11 and 12 the X situated on the course of the ocellar S denotes the position from which the ocellus indicated in each case is supposed to have disappeared by atrophy.

A STUDY OF THE CHOROID PLEXUS.

(Abstract)

BY WALTER J. MEEK.

With the exception of scant references in the standard anatomies very little material treating of the choroid plexuses is available to the general student, and in fact many questions of interest concerning these structures still remain unanswered. The object of the author has been to review the subject up to date and to give the result of his own investigations. The work was carried on in the Neurological Laboratory of the University of Chicago.

On account of their size and their accessibility the plexuses of the lateral ventricles were used exclusively. Mammalian material was studied from the following forms: white rat, rabbit, guinea pig, cat, dog, sheep, and man.

The number of fixatives adapted to the plexuses is somewhat limited. Bouin's fluid, Carnoy's solution, and acetic sublimate proved most satisfactory. For small animals the best results were obtained by fixing the entire brain. The period of fixation was shortened in all the fluids. The usual methods of embedding in paraffin and sectioning were employed. Many stains were used but the most satisfactory results were obtained with iron haematoxylin followed by acid fuchsin.

The choroid plexuses of the lateral ventricles are due to an ingrowth of the pia mater pushing the mesial wall of the hemisphere into the ventricles. The neural wall is of course preserved but it consists only of a simple epithelium. The plexuses are then thin laminae covered with an epithelium, beneath which is a connective tissue stroma containing an extraordinarily rich network of blood vessels.

In many animals the laminae are smooth but in others they are covered with projecting villi. Between these two extremes are to be found all the intermediate gradations. The guinea pig, mouse, and rat possess plexuses that are smooth. In these forms there are prolongations and projections of the folds, but the typical villi are absent. Villi are scarce in the chicken, duck, and pigeon, more abundant in the hog, while they reach a considerable development in the horse, ox, and especially among crocodiles and some of the selachians. In the rabbit the laminae are very irregularly folded but not villous. Villi are numerous along the free edge of the plexus in the sheep. In man villosities are found but the type is somewhat intermediate.

It is generally believed that the choroid plexuses are largest in the embryonic state and that their volume diminishes as the brain reaches its full development. The model of His for the three month human

foetus shows the plexuses as large swollen glandular organs occupying practically all the space in the lateral ventricles. Along with this anatomical fact has grown the idea that the plexuses furnish some kind of a fluid food necessary to the brain during the embryonic period. Accordingly it has sometimes been called the "cerebral placenta". Whatever the case may be in man it seems that the above description does not apply to all forms. In the white rat the size of the plexuses has been carefully studied at various ages. There is a steady gradual growth from the time of the first invagination until the adult appearance is reached. At no time is there any evidence that the organ is enlarged or distended, or that it fills anything like all the ventricular space.

From a freshly killed animal the plexuses may be removed and examined in cerebro-spinal fluid or in normal salt solution. Not a great amount of detail can be obtained in this way, still it serves as a control for the sections subjected to reagents. The cells appear uniformly granular with nuclei shadowy and cell boundaries indistinct. The most careful examination has failed to show the presence of cilia in the adult forms. They are present in young animals immediately after birth, but it seems reasonably sure that cilia are not present in the adult. At the same time cilia are often noticed on the ependyma which has been torn from the ventricular walls.

Under the influence of fixatives and stains many other details appear. The cross section of a small loop of an adult rat's plexus shows the following structures. In the centre of tth section are one or more capillaries. These consist of a delicate endothelial intima which is strengthened by connective tissue cells and fibrils. Between this adventitia and the epithelium are more connective tissue cells and their processes. The epithelium itself is composed of cubical cells which in cross section average about 10-12 micra in width and 8-10 micra in height. Basal and lateral walls are poorly defined but may usually be distinguished as hazy lines. The free edge of the cell is slightly convex. It consists of a thin apical plate or cuticle. The cytoplasm is finely reticular. In the meshes are deeply staining granules which are often collected into small irregular masses. The reticulation for the most part is more pronounced near the periphery. The nuclei are circular in outline and centrally located.

Embryologically the epithelial cells are derived from the inner layer of the neural tube which also produces the ependymal cells. The ependymal and epithelial cells are therefore parts of the same layer, and this may be plainly seen by tracing the plexus back to where its epithelial covering joins the ependyma lining the ventricle. The two types of cells pass into each other by an easy gradation. The epithelial cells have lost all projections from the base which is so characteristic of the ependymal cells. The epithelial layer has also lost all traces of the neuroglia which normally overlies the ependyma.

The epithelium of the plexus consists of but a single layer of cells. In pathological conditions there may be a proliferation and even a stratified condition, but in normal tissue this seems never to be the case.

intercellular spaces occur in the ependymal tissues of many animals, but such cavities are wanting between the epithelial cells of the plexus. Gold preparations show that nerves are present in the vicinity of the large blood vessels. These are probably vaso motor fibers.

In regard to capillaries, connective tissues, and endothelium the plexuses from other forms show but little variation from what has been described in the white rat. The greatest differences are found in the epithelial cells. In this layer the rabbit differs strikingly from the rat. The epithelium of the rabbit is characterized by the presence of clear spaces in the cells. They are from 2-6 micra in diameter and very numerous. Their contents are dissolved out by elcohol, ether, and xylol. In ordinary stained sections they show as clear oval or round areas. The contents are of a fatty nature as can be shown by their staining readily with osmic acid and Sudan III. These droplets are largest at the apex of the cell. Sometimes one may be seen lying half within, half without the cell. This shows that they are expelled through the top wall. During this process the nucleus remains normal, but rarely it may be pressed in to one side by the droplet. These droplets have not been found in the plexus of any other form studied. These clear spaces may be seen in the fresh tissue and for this reason it is not believed that they can be due to any error in technique. Since their occurrence is not general in the forms studied it is not believed that they represent the chief secretion of the cells. It is therefore best to consider them as of secondary importance.

A second point in the rabbit's plexus is the development of the parietal structures at the apex of the epithelial cells. In the rat the marginal zone is at best but a double contoured line. In the rabbit however it is wider and composed of filaments placed perpendicular to the surface of the cell and imbedded in some kind of an interstitial substance. This gives the cells the appearance of ciliation. The structure is what Vignon (1) describes as the "bordure de brosse" or filamentous plateau. Cytoplasmic microsomes at the base of the filaments simulate basal bodies. Terminal bars may be seen in cross section at the corner of the cells.

The plexus of the dog differs little from that of the rabbit except by the absence of droplets. The epithelial cells in the guinea pig are characterized by a great many nucleoli.

The preceding description has referred entirely to the adult plexus. If a late foetal or newborn specimen be examined striking differences will be noticed. The epithelial cells differ from those of the adult in three particulars: shape, staining power, and location of the nucleus (2). To illustrate, the cells from the plexus of a one day old rat may be compared with those of an adult. In the one day form the epithelial cells are narrower and deeper. Many measurements give the following averages. Cells from the one day rat are 13 micra in height and 8 micra in

(1). Vignon. Recherches de Cytologie Generale sur les Epithelium. Archiv. de Zool. Ex. et Gen. t IX, p. 371, 1901.

(2). The attention of the author was first directed to this shift in position of the nucleus by Dr. Hatai of the Department of Neurology in the University of Chicago. The entire study began from an investigation of that point.

width. Cells from the adult are 9 micra in height and 11 micra in width. The contents of the cell in the young form are well nigh unstainable at least by ordinary methods. The nucleus stains diffusely and a small amount of cytoplasm at the apex takes up stain but the remainder of the cell remains clear save for a few radiating lines of microsomes. The location of the nucleus in the one day rat is peripheral while in the adult it is central. In the former it averages 7 micra from the base while in the latter it is only at a distance of 2 micra. As the rat grows older a gradual change in all these particulars takes place. The cells widen, begin to take up more stain, and the nucleus moves toward the center. By the seventh day the cells have assumed the adult type.

These same changes in the epithelium after birth have been noted in the cat and rabbit, and doubtless they occur in other forms. The primitive cylindrical condition of the epithelial cells is evidently retained until extra-uterine life is well begun. Whether this means that the cells do not function until adult life cannot be said. It would indicate that their work could not be the same as in the adult.

Thus far we have studied the plexus in what might be termed its resting stage. Careful examination shows that there are always some cells in any plexus that have the appearance of secretory phenomena. For many years there has been a suspicion that the choroid plexuses secreted or at least aided in the secretion of the cerebro-spinal fluid. But until recently the idea remained without much supporting evidence. Capelleti (1) in 1899 made use of a cerebro-spinal fistula to study the effect of drugs on the flow of the cerebro-spinal fluid. In 1902 Pettit and Girard (2) went a step farther by administering drugs to animals and then removing the plexuses to find whether there were any evidences of secretion in the epithelial cells. The writer has made experiments along the same line as these investigators. No claim is made for originality but the results may be of interest since in some cases other forms were used for study.

By cleaning away the musculature from the back of the neck a glass canula may be inserted through the dura into the fourth ventricle and the cerebro spinal fluid secured as it is secreted. Dogs were used for these experiments. In etherized dogs the insertion of the canula is followed by a rapid rush of fluid. This is due to the rapid secretion under the influence of the ether and a consequent accumulation of the fluid. The flow from the ether persists for about thirty minutes but gradually decreases. If 1% pilocarpine now be injected through the femoral vein the secretion becomes stronger and reaches a maximum of 3 to 4 drops a minute. An injection of atropine will now abolish the secretion entirely.

Microscopic examination has been made of the plexuses of dogs and rabbits that had been under the influence of ether for 20 minutes, and also of rabbits, guinea pigs, and rats injected with muscarin. The latter drug was most useful when diluted to 1-500.

(1) Capelleti Archiv. Ital de Biol. XXXVI. p. 299-302, 1901.
(2) Pettit and Girard. Archiv. d' Anat, Mic. tV. p. 213-264. 1902-1903.

In the rat experiments with muscarin did not give decisive results but in the case of rabbits and guinea pigs the results were definite. Often as many as two-thirds of the cells showed evidences of secretion. Normally the epithelial cells of the rabbit are about 6 micra high but after the injection of muscarin the height increases to 12 micra. A differentiation into an outer clear zone and a basal granular zone is rather well marked. Granulations are heavier toward the base of the cell. Clear spaces begin to appear toward the top and rarely does the stainable cytoplasm extend to the upper cell wall. Large masses of granules occur in the upper part of the cell where the lines forming reticulations cross. The nucleus remains globular with a clear outline. The things most striking about these modified cells are their great increase in height and the appearance of so much clear space at the apical end.

Parietal structures are not supposed to take any part in the functional activity of epithelial cells. In case of the extrusion of droplets they may be opened but there is no change in their structure during the process. In the case of the rabbit where there are fatty droplets which we consider a secretion of secondary importance, we can find no evidence of any change in the marginal zone of the cell. In the case of the normal secretion, however, the evidence seems to be that the marginal zone of the cell is modified. The apical wall seems to decrease in thickness as the cell increases in height. We do not believe that it disappears during the secretion but it evidently is considerably modified.

The fact that the flow of the cerebro-spinal fluid is increased by the injection of drugs that produce secretory phenomena in the epithelial cells, justifies the conclusion that the fluid is secreted by the choroid plexuses. No doubt the ependymal cells may have their part in the production but it is certainly a minor one compared to that of the plexuses. Additional evidence that strengthens this conclusion is the occurrence of hypertrophy of the plexuses in certain cases of hydrocephalus. The fact that the fluid differs from serum or lymph is also evidence that is in favor of this view.

THE CAROTID ARTERIES AND THEIR RELATION TO THE CIRCLE OF WILLIS IN THE CAT.

BY H. W. NORRIS.

The value of the domestic cat as an object of dissection in work introductory to comparative anatomy in general and to mammalian anatomy in particular, makes it important that our knowledge of this form should be as exact as possible.

Of the comparatively few works that deal specifically with the anatomy of the cat only three attempt any detailed description of the smaller subdivisions of the carotid arteries. These descriptions are so at variance with each other and with the actual structures as found by the writer that it would seem that in some cases they must be based upon individual variations or aberrant conditions. That blood vessels in general are subject to great variations in their individual relations is well known. This is as certainly true of the carotid arteries as of other blood vessels. This paper is based upon specimens whose arteries were injected through the dorsal aorta with chrome yellow starch injection mass. They were prepared for ordinary student dissection and not for any special investigation.

One of the most striking characteristics of the published descriptions of the carotid arteries of the cat is the contradictory statements made regarding the origin and distribution of their branches. According to Mivart[1] the internal carotid artery is "a very minute vessel" that arises from the common carotid, passes into "a slender canal between the basi-occipital and basi-sphenoid, and the adjacent part of the temporal bone", and enters the cranial cavity by the middle lacerated foramen. Reighard and Jennings[2] state that it arises near or in common with the occipital artery, passes anteriorly along the ventral border of the auditory bulla, and enters the latter together with the Eustachian tube, to pass into the skull by the middle lacerated foramen. Wilder and Gage[3] say that the internal carotid "passes along the carotid canal and unites with a larger vessel extending along the mesal side of the bulla". Tandler[4] states that by a common trunk from the common carotid there arise three arteries: the internal carotid, the occipital, and the ascending pharyngeal. He is essentially in agreement with Mivart as to the passage of the internal carotid through the bulla into the skull. The internal carotid artery of Reighard and Jennings is the ascending

1. Mivart, St. George. The Cat. New York, 1881.
2. Reighard, J. and Jennings, H. S. Anatomy of the Cat. New York, 1901.
3. Wilder, Burt G. and Gage, Simon H. Anatomical Technology as applied to the Domestic Cat. New York, 1886.
4. Tandler, J. Zur vergleichenden Anatomie der Kopfarterien bei den Mammalia. Denkschr. d. Math-Naturwiss. Classe d. kaiserl. Akad. d. Wissensch. Wien, Bd. LXVII, 1898.

pharyngeal of Tandler. The latter vessel arises separately from the common carotid, or together with the occipital, or from the common trunk as described by Tandler. It passes anteriorly along the median ventral border of the auditory bulla and after giving off branches to the wall of the pharynx enters the auditory bulla along with the Eustachian tube and at the middle lacerated foramen joins the internal carotid. Wilder and Gage are the only ones who have heretofore recognized this union of the anterior pharyngeal with the internal carotid. The two arteries are not usually equaly well developed; where one is of considerable size the other is likely to be vestigial.

The writer finds no evidence to support the statement of Tandler that there are two auricular arteries arising from the external carotid. Tandler is also in error in saying that the superficial temporal and transversal fasciei arise by a common trunk from the external carotid just anterior to the ear. This common trunk divides as described by Reighard and Jennings into a superficial temporal, a branch to the masseter muscle, and an auricular branch. At about the same level as that of the inferior alveolar artery, that is, opposite the condyloid process of the mandible, arises an artery that supplies the deeper muscles of the temporal fossa. Mivart speaks of a branch "going to the muscles of the temporal fossa", but he evidently refers to the superficial temporal. Reighard and Jennings describe an artery arising at this level, but call it the middle meningeal, although in one of their figures the branch called middle meningeal is represented as running antero-dorsally into the temporal fossa. This artery going to the deeper portions of the temporal muscle probably represents in part the *A. temporalis profunda posterior* of human anatomy, and properly may be designated as such here. According to Mivart the meningeal artery arises from the carotid plexus and passes into the skull through the sphenoidal fissure. Reighard and Jennings state that the middle meningeal starts from the internal maxillary at about the same level as the inferior alveolar and enters the cranium through the foramen ovale. I find that the middle meningeal artery arises variously. More often it arises from the intracranial portion of the carotid plexus. Less frequently it takes its origin essentially as described by Reighard and Jennings. Occasionally it springs from a vessel that runs from the internal maxillary artery through the foramen ovale to the intra-cranial part of the carotid plexus. In most cases the small branch of the internal maxillary that enters the foramen ovale has nothing to do with the middle meningeal artery, but passes to the posterior surface of the tentorium. The branch figured by Reighard and Jennings as the middle meningeal is evidently the posterior deep temporal. The latter arises at the point where the external carotid makes a sharp dorsal bend, and passes antero-laterally and dorsally across the ventral median portion of the condyloid process of the mandible into the temporal fossa.

In the region of the sphenoidal fissure the internal maxillary artery gives off a number of small branches that by subdivision form the carotid plexus about the exit of the maxillary branch of the trigeminal nerve.

Reighard and Jennings are incorrect in stating that the internal maxillary after giving off the middle meningeal artery "divides into three or four branches", which "redivide and the twigs form a complicated plexus, the carotid plexus". I agree with Tandler that the internal maxillary artery does not completely break up into the plexus, but its main trunk passes through the network of vessels formed from the small branches above mentioned. In many cases the vessels to form the plexus begin to appear as far back as the inferior alveolar artery. One small branch commonly arises from the base of the deep temporal artery. A small muscle, that runs from the external pterygoid fossa to the extreme inner border of the condyloid process of the mandible, is partly enclosed in the posterior part of the plexus. This muscle seems to have escaped previous notice.

From the carotid plexus there arise a number of small vessels, and as one might suppose, they are subject to considerable individual variation. From the inner border of the plexus spring three or four vessels that pass into the skull through the sphenoidal fissure and after uniting into a single trunk join the internal carotid artery. The latter vessel then joins the circle of Willis. The circle of Willis is formed by the union of the two lateral divisions of the basilar artery with the median cerebral arteries. At the point of juncture the internal carotid artery unites with them. Or we may adopt the view of Tandler that the internal carotid unites with the intra-cranial part of the carotid plexus, and that the latter joins the circle of Willis. That the carotid plexus in the cat is in any way connected with the circle of Willis seems to have been overlooked by Mivart. According to Reighard and Jennings a large branch of the carotid plexus passes into the skull through the sphenoidal fissure and divides into a short posterior communicating branch with the internal carotid, and into the median and anterior cerebral arteries. Davison[5] does not give any description of a communication between the carotid plexus and the circle of Willis, but in one of his illustrations such a connection is certainly figured. I find no evidence of the occurrence of a posterior communicating branch in the sense in which Reighard and Jennings use that term. For according to them the internal carotid unites with the basilar artery, or the posterior cerebral branch of the same, and the intra-cranial branch from the carotid plexus joins the anterior and median cerebral arteries. Then between the median cerebral and the internal carotid arteries there is supposed to occur a communicating branch. There may be recognized a vessel that corresponds to the posterior communicating branch of the circle of Willis in man, but this is quite different from that which Reighard and Jennings believe to occur.

From the dorsal side of the carotid plexus is given off a small branch that almost immediately passes into the cranial cavity through a small foreman between the alisphenoid and the orbitosphenoid bones and is distributed to the dura mater in the anterior part of the cranium. It

5. Davison, A. Mammalian Anatomy with special reference to the Cat. Philadelphia, 1903.

should be called the anterior meningeal artery. The small foramen between the alisphenoid and the orbitosphenoid bones through which the anterior meningeal enters the skull, apparently has been recognized by Jayne[6] alone. He figures it but does not describe it or name it. From the plexus there run a number of small vessels to the pterygoid, masseter, and temporal muscles. At the antero-lateral border of the plexus there are usually two branches larger than the other muscular branches, that pass laterally between the orbit of the eye and the temporal muscle, and are distributed to the latter. They seem to correspond to the *A. temporalis profunda anterior* of man. Tandler speaks of them as the deep temporal branches. I am unable to identify the bucco-labial vessel that Tandler says passes laterally from the plexus. Close to the origin of the deep temporal branches from the plexus there arises a branch that passes dorso-medially around the border of the structures in the orbit and enters the skull though the ethmoidal foramen in the frontal bone. In its course it gives off a lachrymal branch to the lachrymal gland and adjacent region, and a frontal branch to the region of the upper eyelid. This is evidently the vessel from the carotid plexus that Reighard and Jennings call the ophthalmic artery. But it does not supply all the structures in the orbit, very few muscles receiving vessels from it. Only in part does it correspond to the ophthalmic artery of man. It were better named the ethmoidal, as its main portion is the ethmoidal artery. According to Tandler a common trunk arising from the internal maxillary artery divides into the lachrymal, ethmoidal and frontal arteries. I find that this common vessel arises from the carotid plexus rather than from the main artery, but it is quite likely that the origin described by Tandler occurs sometimes. The muscles of the orbit for the most part receive their blood supply from small vessels of the plexus, but there seems to be no regularity in their arrangement. From the internal maxillary artery in the midst of the plexus there passes into the orbit a vessel of considerable size. This artery after a somewhat tortuous course through the plexus goes to the eyeball along with the optic nerve. It gives off a pair of arteries that enter the eyeball at about the equator of the latter, and that evidently correspond to the long posterior ciliary arteries in man. Many other smaller short banches are given off to the posterior wall of the eyeball, and may be designated as the short posterior ciliary arteries, since they have the same general distribution as these latter arteries in man. The central artery of the retina enters the bulb along with the optic nerve. and is a very small vessel. This vessel supplying the eyeball is the ciliary artery. Tandler states that it arises from the carotid plexus. It may have such an origin occasionally, but in general it comes directly from the internal maxillary artery. Near the eyeball it is joined by one or two small vessels from the plexus. At about the same region there sometimes unites with it a vessel that emerges from the cranial cavity through the optic foramen. This latter vessel may be traced to the circle of Willis a little posterior to the point of divergence of the anterior and median cerebral arteries. This vessel arising from the circle of

6. Jaynes, Horace. Mammalian Anatomy, Part I, The Skeleton of the Cat. Philadelphia, 1898.

Willis and passing into the orbit is beyond question the ophthalmic artery. It may be a well developed large vessel, or rudimentary, or merely vestigial, or apparently, even absent. Tandler is the only one who has recognized the occurrence and the homology of this vessel. From the antero-median border of the carotid plexus there run one or two small branches that soon unite and pass as a single vessel into the skull through the optic foramen. Here it unites with its fellow of the opposite side, runs anteriorly and after anastomosing with branches of the ethmoidal and anterior cerebral arteries forms a meningeal network in the dura of the olfactory fossa.

The other branches of the carotid arteries and of the circle of Willis seem to need no additional description beyond that given by Reighard and Jennings. It has seemed worth while to describe the vessels that the ordinary student finds either undescribed or described so incorrectly as to cause confusion.

THE DISPARITY BETWEEN AGE AND DEVELOPMENT IN THE HUMAN FAMILY, ILLUSTRATED BY PRONOUNCED CASES DUE TO THYROID MALFORMATIONS.

BY JAMES FREDERIC CLARKE.

Plates XIX-XXVIII.

The author of Rip Van Winkle has his hero awaken from the long sleep, an old man. The writer does not violate in fiction our conception of the uniform advancement, in human growth and development, from infancy to old age. So uniform is growth in children that we associate in our minds rather definite sizes and mental conditions with certain years from birth. Dress patterns are made for a three or an eight year old girl. A shoe merchant can usually select correct shoes for your boy if he is told the age. There is not great variation from the average age of the majority of the pupils in any particular grade of the common schools. (Note I). I find that the age of learning to walk, cutting the first tooth, of speaking words and forming sentences is comparatively uniform among healthful children of the same class. (Note II.)

However, all of us know of marked exceptions to this rule of uniformity in development. A precocious child now and then varies widely from the average and seems far in advance of his calendar age; or a "backward" boy may begin dentition or walking months later than is usual for children. These marked variations are found in so-called "normal" individuals. Beyond this, abnormal variations occur, reaching from dwarfism to giantism in the physical or from inbecility to genius in the intellectual development.

The causes of these variations in development are numerous; some acting throughout the individual's life while others for a brief period delay or advance the mental or physical growth of the child. It is my purpose to present for your consideration but one—perhaps the most striking—example of variation in development. A condition, called Cretinism, that has been studied to some extent by physicians in their professional work, but, as far as I can learn, is as yet almost unnoticed by teachers and psychologists. It may be healthful in these days of popular "mental science" to study an intellectual abnormality due to a material cause and corrected by a material treatment.

In some parts of Europe it is common to find these individuals who at an early age experience an almost complete cessation of physical and mental development due to a congenital absence or loss of function of the thyroid gland. The cause of the condition was for long mistakenly supposed to be some peculiarity in the drinking water or the soil.

On this continent the condition of Cretinism has been supposed to be rare. Dr. Osler in 1897 was able to report but sixty cases in the United States. I have knowledge, at this date, of but nine such individuals in Iowa.

The ductless thyroid gland in health is so inconspicuous that some, even in this audience, may not be aware of its location in the front of the lower part of the neck. When enlarged it forms the goitre so frequent as to be familiar to all. On section the ascini of this gland may be found filled with a colloid material which is not yet thoroughly understood. In just what way the secretions of this gland influence our system is not yet definitely determined. The fact is well established, however, that if the function of the thyroid is abrogated the individual so affected experiences an almost complete cessation of physical and mental development.

The child without a thyroid gland appears at birth normal. It must in its uterine life receive the mother's thyroid secretions through the placental circulation. Soon after birth—as early as the second month—the abnormal condition begins to appear. It is probable that the mother's milk in part supplies a stimulus to growth for the development is usually more rapid during the first year than at any later period. In my personal experience the early development has been proportioned to the supply of nourishment from the mother's breast. When this is abundant and long continued the baby finally attains the stature of the normal child of three years of age. Then growth in height practically ceases. The phenomenon is striking in the extreme. Dentition, growth, speech, mental acquirements and the development of puberty are delayed or arrested. The infantile state is prolonged indefinitely and a merely vegetative existence supervenes. There is a deposit of a mucoid substance beneath the skin which produces some deformity and a peculiar appearance easily recognized.

When such an individual is discovered, then one of the triumphs of modern medicine is made possible for at any time from the first to the twentieth year (and possibly later) in the life of the Cretin, growth and development will be resumed (in most cases) if the products of the thyroid gland of some animal are supplied as a food. This today is accomplished by the artificial feeding of the dried and compressed thyroid gland of the sheep.

As typical illustration of this curious condition, it is my privilege to present to you a series of photographs of two Iowa girls who exhibit sporadic Cretinism due to a congenital absence of the thyroid gland. The first was two years old for eighteen years and then, after thyroid feeding was begun, she rapidly advanced through a belated childhood. For her the years from two to twenty have been of little consequence. While time stopped for her the other children of the family were born, passed puberty and attained mature stature. Now these actually younger brothers and sisters treat this older sister as a baby without realizing the anomaly.

This girl cut her first tooth at twelve months—eight months later than the other children. When one year old she lost animation and developed oedema, but began to walk. After three years of age she sat in a chair continuously, never walked of her own volition—only when urged to move. She rarely spoke and only in answer to questions. She increased in height to her sixth year and in weight to her sixteenth year. When seventeen years old she cut three of her second teeth.

At twenty years and four months of age I found this girl 36.5 inches in height and weighing thirty-nine pounds; the typical height of a child of three years—the weight of a girl of five years of age. She retained her first teeth with three of the second set just through the gums. She spoke but few words in a harsh frog like voice and sat apathetically in a chair moving only when urged to do so. She did not exhibit the intelligence of a normal child of two years.

At this time the artificial feeding of sheeps' thyroids was begun and in two weeks the beginning of the transformation shown in the photographs was noticeable. During the next few months the short harsh hair fell out. The second dentition progressed, was completed. The weight, at first decreasing, soon rapidly increased. The height in four years increased 7.5 inches. The same increase as is normal for a girl from her third to her seventh year.

The mental awakening paralelled the bodily transformation. The voice softened. The child learned to talk, to smile, to play and to think as normal children do these things. In the first year of her treatment she wore out a pair of shoes for the first time in her life. She now goes to school, plays with dolls and aside from her bowed legs, flattened nose and as yet too low pitched voice is to all intents a child of five years of age. In the fantasies of fiction I recall no stranger scene presented than this family group with one child for whom eighteen years are not counted.

So long was this lost interval that I doubt if her life will ever now reach its full stature. The decreasing increments of gain by months now indicate that this girl will always be a dwarf and will probably never reach the average adult intellectual development. She is, though, progressing as are other children of her age—the age reckoned without the years of inactivity. She now is three feet nine inches in height and weighs seventy-six pounds. A gain of eight and one-half inches and of forty pounds since she began taking thyroids.

The second Iowa Cretin of which I present photographs was discovered earlier in her life of inactivity. In the ninth year of her age I began the feeding of thyroids. Her condition was similar to that of the other child but her transformation has been more rapid. The photographs show the change better than words can describe it. Now three years after beginning the treatment she is a bright, active, happy girl of an age less the years of her inactivity.

My purpose in presenting to the Academy these striking illustrations of extreme variation in development is to suggest to teachers the possibility of an explanation of lesser variations from the normal average

of growth in children. If the absence of the thyroid gland will cause cessation in development is it not probable that disturbances in this gland's activity will cause lesser variations in growth? Periods of apathy or of nervous excitement in children; delayed dentition and belated ability to talk may mean a temporary disturbance in the gland function and not a less number of brain cells.

Then too, the thyroid is but one of several ductless glands which we harbor in our anatomy and though speculation on the subject is as yet valueless, I am inclined to think that we may hope for much help in these subjects from the physiology of the future.

NOTES.

I. Statistics kindly furnished me by the teachers of the Fairfield, Iowa, schools show:

1. Children of the same class in the grammar school vary four years in age.

2. More than three-fourths of each class are within one year of the average age.

3. Nearly every class has but one or two individuals varying widely from the average age and usually in these exceptional cases the teacher is aware of a definite cause, such as the lack or the advantages in earlier training.

4. In nearly all classes the average age for girls is less than that of boys; the average being seven and one-half months.

II. In the most intelligent families of my home town, where the mothers have kindly furnished me data, the usual age for beginning the first dentition is from the sixth to the tenth month. Average of those studied nine months. Walking is begun from the tenth to the thirteenth month; average 11.6 months, and the first word is spoken from at 8.5 to 12 months; average 10.5 months.

In several instances an attack of sickness at the usual time for these events has delayed the development two or three months. In one instance a child spoke several words at ten months, then stopped speech altogether until eighteen months of age, when she began again to learn to speak words. This was during apparent good health.

RELATION OF THE MOTOR NERVE ENDINGS TO VOLUNTARY MUSCLE IN THE FROG.

BY B. A. PLACE.

Plate XXVIII.

This is a subject upon which most authorities differ widely, and few, if any, agree upon all points entirely. It is therefore, an inviting field for research. Because of the extreme diversity of opinions current it has seemed best to me to formulate them in a brief way before giving the results of my own observations.

It seems to be generally agreed that there are at least some nerve endings distributed to every voluntary muscle fibre. As nothing to the contrary has been found in my work this matter will not be referred to again in this paper. The points on which difference of opinion are based are as follows, and will be discussed in the same order. (1). Is there an end plate or localized accumulation of specialized muscular tissue in which the branches of the axis-cylinder terminate? (2). What is the relation of the ultimate branches of the axis-cylinder to the sarcolemma? (3). Where does the sheath of Henle stop, also the medullary sheath and the neurilemma? (4). What is the appearance and disposition of the ultimate branches of the axis-cylinder?

The Huber-Dewitt paper states that "Kühne deserves the credit of the discovery that the axis-cylinder terminates under the sarcolemma in the nucleated granular substance which he describes as the sole (Sohle); the nuclei as sole nuclei (Sohlenkerne)". It also states that Kuhne makes the hypothesis that the sole is "muscle protoplasm sarcoglia or sarcoplasm, while the nuclei of the sole might be likened to muscle nuclei". To quote them still further: "This interpretation of the granular sole and its nuclei suggested itself to us before Kühne's similar observation was definitely understood." They add this feature to its description: "As is well known in Amphibia, the axis-cylinder of the motor fibre terminating in striped muscle does not end in a localized area (birds, reptilia and mammalia), but ramifies over a proportionately much larger area. Conditions here presented are therefore very similar to those in such as present a localized motorial ending with the distinction that in the later the axis-cylinder terminates in a localized elevation—the sole—which has been interpreted as a circumscribed accumulation of sarcoplasm surrounding the ramified ending of the axis-cylinder and extending like it over a larger proportionate area of the muscle fibre." Wilson makes this statement denying the existence of any ground plate at all: "In the frog's muscle the nerve ending has no ground plate in

which the branches ramify." Sihler thinks that what has been seen in this regard by Kühne and others is derived from Henle's sheath. To quote: "I find that the so-called 'Sohlenstanz' of Kühne is derived from Henle's sheath."

Huber-Dewitt conclude that the end branches of the axis-cylinder are entirely under the sarcolemma. To use their own language: "Two cross sections are shown in Figs. 13 and 14. It may here be seen that the ramifications of the axis-cylinder are under the sarcolemma terminating in a relatively thin layer of sarcoplasma." Kühne is mentioned by them as holding a similar view. According to Sihler, Engelmann, Klein, Gerlach, Frey, and Waldeyer are also of this same opinion. Sihler himself, however, concludes that with perhaps some qualifications these end-branches are epilemmal. The following statements from him will serve to show his position: "The endings of motor nerves in striped muscle remain on the outside of the sarcolemma. What may be the exact condition of things at the points where muscle and nerve fibre are in actual contact—whether the sarcolemma and neurilemma are wanting there or perforations exist—I cannot say. The precise relation of muscle to nerve here is an unsolved and difficult problem." Dogiel in the following language states that they are hypolemmal "die Marksubstanz aber sammt dem Achsencylinder tritt unter das Sarcolemma". Huber-Dewitt quote Rhetzius as being in doubt whether the end branches are epi- or hypolemmal. Wilson takes the view that the larger branches of the endings lie over the sarcolemma and at some distance from it, while small fibrillae possessing a terminal knob come off lying either within or under the sarcolemma.

Sihler states that Henle's sheath ends before the muscle fibre is reached and is open so that the axis-cylinder with its neurilemma appears like an arm emerging from a sleeve, while the sheath of Schwan covers the end fibres down to their tips and is provided with nuclei. Huber-Dewitt thinks that the sarcolemma and neurilemma become continuous with each other at the point where the nerve fibre, as they claim, pierces the sarcolemma. This small area made up of both sheaths they call telolemma and its nuclei if any are found at this point, telolemma nuclei. The following statement from Dogiel will show his attitude: "In ersten Falle tritt die markhaltige Nervenfaser an irgend eine Stelle der Muskelfaser heran, verliert in dem Sarkolemma ihre Schwan, 'sche und Henlische Scheide" which practically agrees with the last preceding writer.

As to the appearance and disposition of these ultimate branches, Dogiel thinks they are devoid of any sheath, are thickened, toothed and run along the muscle fibre frequently ending in a knob. He thinks they neither go to any neighboring muscle fibres nor form any plexuses. Wilson thinks on the other hand that they are covered by a sort of a sheath formed from the ordinary nerve coverings and the sarcolemma, but are non-medullated. He also thinks that some of them end in the intermuscular connective tissue, and that others go to neighboring fibres. Plexuses are found at times also, he thinks. Sihler remarks that the

nuclei of the neurilemma on these fibrils have more of a tendency to roundness and that the individual fibrils end as such and not in a bulb. He states that the endings have little of the medullary sheath.

This investigation was begun in 1904, and was presented in somewhat different form to the faculty of Ohio University in June, 1905, as a thesis for the degree of A. M. Research has been continued since then as time would permit. The animal thus far used for observation was the common North American toad (*Bufo lentiginosus*) and the method employed essentially that of Sihler's. The microscope chiefly used has a Zeiss aprochromatic oil immersion two millimeter lens.

Fresh tissue was macerated, stained, teased, and mounted in glycerine on slides.

The macerating fluid is made as follows:

Ordinary acetic acid	1 part
Glycerine	1 part
Chloral hydrate 1 per cent. solution in distilled water	6 parts

The muscles should be in bundles of not more than three or four millimeters in diameter. Those of the foot or fore limb of the toad or frog are already of convenient size.

The staining material is prepared as follows:

Well ripened Erlich's Haematoxylin	1 part
Glycerine	1 part
Chloral 1 per cent. solution in distilled water	6 parts

The muscle should be macerated from 12 to 20 hours depending upon the age of the animal. It would do no harm to use stronger acetic acid for older animals. The object is to dissolve the inter-muscular connective tissue, which is accomplished when the muscle no longer offers much resistance to teasing. One should begin testing the matter as soon as 12 hours have passed. When properly macerated the tissue should be left in glycerine until it becomes saturated, which requires about two hours.

Before putting the tissue into the staining fluid it should be further teased into bundles not more than one or two millimeters in diameter. All teasing should be done in glycerine. Staining requires from 3 to 10 days. When properly stained the muscle fibres have a color ranging from wine color to nearly black. Nervous and muscular material are stained almost black, while connective tissue remains quite pale. The darkened nuclei of the capillaries which are everywhere so abundant are a good index to the intensity of the staining process, since nerve structures take the stain at about the same rate with them. All the parts do not stain uniformly. Parts that are over-stained can be readily reduced in color by subjecting them to a weak solution of acetic acid. A convenient way to accomplish this is to immerse them in glycerine, to which has been added a small amount of acetic acid. The stained tissue may be kept unchanged almost indefinitely in glycerine.

A convenient way to find nerve structure is to tease quite a number of muscle bundles still smaller until each remaining part contains perhaps half a dozen fibres. These in a shallow glass dish may be examined

under 50 to 100 diameters and the ones best showing nerve structures sorted out. These latter mounted in glycerine on slides will flatten out under slight pressure upon the cover glass so as to enable one to continue the examination with higher power of the microscope. These structures are quite delicate and when once mounted cannot be further manipulated for different views. For this reason there is an advantage in mounting material between large cover glasses in as much as both sides of the preparation may then be viewed. There is this disadvantage, however, that such a preparation cannot be preserved long.

In addition to the above process stained tissue was hardened in alcohol, embedded in paraffin, sectioned and examined in series. Various counter stains were employed but with very little success thus far.

As to my own results I am convinced that the primary nerve fibre neither terminates in an end or ground plate, or granular sole, nor pierces the sarcolemma, at least at that point. It would seem to me that the sole nuclei described by Huber-Dewitt and others were end bulbs belonging to the ultimate branches of the axis-cylinder. For by this method unless a particular preparation is stained quite perfectly only a few of the end fibrils can be traced, while their granular nuclear-appearing bunches or knobs appear quite conspicuous, but disconnected. I was for some time of the opinion myself that these apparently isolated knobs belonged to the muscle fibre, and that the muscle fibre was consequently specialized at these places for receiving the nerve endings. But by observing that the best stained preparations showed all of these knobs or bulbs to be either connected, or partly so, by fine nerve fibrils, I concluded that such would be the case with all of them if the staining was sufficiently perfect. Later observations confirm the belief. There seems to be no regular order, size, shape or number of either the end fibrils or end bulbs. Generally the fibrils are relatively short and the bulbs are elongated and more pointed at the distal ends. Plexuses among the fibrils are occasionally found. The fibrils show by their pale outline down to their tips a covering of connective tissue which is probably a continuation of the neurilemma. In my observation no neurilemma nuclei have been seen upon them, but this does not argue much for the absence of neurilemma here, in as much as neurilemma nuclei of the main fibre are generally much farther apart than the entire length of these fibrils. These structures seem to be connected more or less with the sarcolemma, as may be seen by their adhesion to that membrane when being torn off. The relation seems to be either that of intermuscular connective tissue joining fibrils and bulbs to the sarcolemma, or a superficial coalescence between neurilemma and sarcolemma. In the examination of a very great number of cross and longitudinal sections no point could be found where either bulbs or fibrils were beneath the sarcolemma. In the fibrils the medullary sheath is either present in very slight amount or is entirely wanting. Figure 1 is fairly typical of this structure. Exceptional forms are occasionally found differing widely from the typical.

The sheath of Henle is a rather robust structure of the primary nerve fibre presenting nuclei similar to those of the neurilemma. The nuclei of neither of these structures seem to have any regular order or position. These two sheaths appear to coalesce at, or slightly distal to, the point where the axis-cylinder breaks up into its fibrils. More evidence, however, is desirable upon this point. The myelin or medullary sheath stains dark, about the same as the axis-cylinder, which would tend to show that this structure was nervous and not connective tissue. Incidentally this helps to settle the question—from what is the myeline sheath derived, whether from the axis-cylinder or from the sheath of Schwann? It is wanting, or nearly so, at intervals known as nodes of Ranvier. Divisions of the axis-cylinder occur at these nodes. These structures are shown in Figure 2.

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KEY TO THE DRAWINGS.

A and B, muscle fibres.

a and a′, nerve fibres.

c and d, branchings other than at points where the axis-cylinder breaks up into its ultimate fibrils.

b—The point where the nerve fibre breaks up into its ultimate fibrils, which is usual soon after the primary fibre comes upon the muscle fibre.

Med. S.—Medullary sheath.
Axis-C.—Axis-cylinder.
Neu.—Neurilemma.
Hen.—Henle's sheath.
Hen.-N.—Nuclei of Henle's sheath .
End. f.—End fibrils.
End. b.—End bulbs.
Plex.—Plexus.
The size of the fibres are exaggerated.

CLADOCERA OF DES MOINES AND VICINITY.

BY B. O. GAMMON.

This investigation was begun in April, 1901 and collections were made at various intervals during that spring. During the summer of 1901 eight or nine weeks were spent in collecting and identifying specimens. Again in the summer of 1902 the work was taken up for about five weeks and during the early part of the summer of 1903 further collections were made. At odd times during all this period new specimens have been noted as they were found in material collected for work in the Drake Zoological Laboratories.

Collections of more or less richness have been made from the following bodies of water:

Zoo Lake.
South Park Pond.
Pools near North Sixth Ave. Bridge.
Pools near Belt Line Car Bridge.
Flood Ponds at East Tenth and Vine Streets.
Forty-second street sloughs.
Waveland Park pond.
Old Fair Ground Lake.
Nourse's Slough.
Slough at Fortieth and Kingman Avenue.
Slough near Camp Douglas.
Casey's Lake.
Sherman's Lake.

In naming these collection grounds the commonly accepted name has been used in all cases where it is known to the writer, otherwise a name has been applied explanatory of the location.

Zoo Lake from which the greatest number of collections were taken, is a horse-shoe shaped body of water located about a half mile north and a little west of Sixth Avenue bridge. Nearly all collections were taken from the east arm which is deepest and largest. The depth is said to be from twenty to twenty-five feet near the center but all collections were made from shore in water not exceeding six to eight feet in depth. Myriophyllum abounds along the entire shore and other aquatic plants are quite common; the water is clear over a muddy bottom. Shore line shaded except at north and south ends. Water always fresh, coming from springs. Buffalo fish are reported quite plentiful and small mud catfish and other small fishes are frequently caught. During extremely high water the Des Moines River is in communication with Zoo Lake and during the floods of July 1902 and May 1903 quite a strong current

was established through the east arm. In the floods of 1903 this current was so strong that collections made some three weeks after the waters subsided were altogether negative in results as regarded living entomostraca.

South Park pond is an oblong body of water about one and one-half acres in area located in South Park about a quarter mile south of South Ninth Street Bridge. It was formed by throwing a dam across a ravine which drains quite an area of land west of South Ninth Street. Its greatest depth is about fifteen feet, though no hauls were made at a greater depth than four to five feet. Green algæ cover much of the shore waters and aquatic plants of higher organization are fairly abundant. The waters are clear and fresh though over a muddy bottom which caused more or less dirt to be caught in the dredge at nearly every haul. Practically the entire shore line is shaded except at the north end. Minnows and small fishes are found here but no large ones.

Sixth Avenue Bridge Pools are long narrow ponds cut off from the river by levees. They lie east and west of the north approach of the bridge and parallel to the Des Moines River with which they communicate during freshets. They are well shaded and water stands here the year round. Those east of the bridge are very weedy and the surface is usually covered with duckweed. The one west of the bridge is open and free from vegetation though shaded. Turtles are abundant here but no fish. Neither of these pools exceeds thirty feet in width though some of them are five or six rods long. Depth ranges to five feet, collections mostly at three. Waters clear.

Belt Line Bridge Pools resemble those of the Sixth Avenue bridge but were much poorer collection grounds.

Flood Ponds at East Tenth and Vine Streets are located in the midst of a network of railroad enbankments, East of Ninth street and South of Vine street in East Des Moines. Only one of them is permanent. It is located between Tenth and Eleventh streets and just South of the Rock Island tracks. Just south of it is another semi-permanent pond from which some hauls were made. Each of these ponds is about three-fourths of an acre in extent. The depth does not exceed two and one-half to three feet. No vegetation is present except occasionally a little duckweed and green algae. The waters are clear, bottom muddy. The water source is overflow from Des Moines River and rain. There is no shade. Fish are never taken though cray-fish and turtles are sometimes seen.

Forty-second Street Slough is a very shallow though permanent prairie slough located about three-fourths of a mile North of the north entrance to Waveland Park. It varies from one-half to one acre in extent, depending upon rainfall. The depth does not exceed two feet. Cat tails and other rushes abound and clover and prairie grasses border the slough and extend into the water for several feet from shore. The water is clear above the weedy bottom. Its source is from surface drainage; no shade. No fish but sometimes a few frogs are found.

Waveland Park Pond is an open pond of about one-half acre in extent, surrounded by grassy and weedy banks. It is located in the north central part of Waveland Park in a low ravine. Its depth is unknown to me

but no collections were made in water exceeding four feet in depth. The water is clear over a muddy bottom with little littoral vegetation. It is the drainage basin of a considerable area of rolling, wooded, bluegrass upland. No shade except on the north. Occasionally turtles but no fish are found here. Water is fresh Only negative results were obtained here, Cladocera or other orders never having been found in any of the collections made from this pond.

Old Fair Ground Lake is an open pond of perhaps four acres extent and comparatively shallow. Part of the shore is overgrown with rushes. Muddy bottom. Water supply from springs and naturall drainage. Few if any fish. Negative results.

Nourse's Slough is a small shallow basin surrounded by weedy marsh. On the north and west are clumps of trees but the east and south shores are open. It is located on North Twentieth street about two miles north of Forest avenue. Crayfish are generally abundant. Waters usually somewhat roiled and often quite foul. Bottom muddy.

At Fortieth and Kingman Avenue, is a shallow slough grown full of cat-tail and other rushes. It is not more than one-fourth acre in extent and does not exceed eighteen inches in depth. Only one collection was made here.

Casey's Lake is a spring fed pond of perhaps five acres extent located near east Twentieth and Court avenue. It is apparently an ideal habitat for Entomostraca being full of grass and aquatic vegetation. The waters are clear above a sandy bottom with duckweed generally covering the entire surface. Its depth ranges to eight or ten feet. Negative results, as regards Cladocera attended all dredging here though a few forms of Copepeda and Ostracoda were usually found.

Sherman's Lake is a long narrow pool about a half mile south of East Ninth Street bridge surrounded by high banks made mainly of coal slack and ashes. No vegetation along shore. The results here were negative as regards all animal forms of the higher phylla.

Camp Douglas Slough is a deep basin of small area about one-fourth mile south of Camp Douglas. It is shaded on three sides but open to the north. Weeds and rushes abound on the banks. Frogs and crayfish are generally abundant and small mud cat-fish are common. Water clear above a muddy bottom. Hauls made at a depth of three to four feet.

The "Birge Cone Dredge" designed by Prof. E. A. Birge of the University of Wisconsin was used in making practically all of these collections.

RICHNESS OF POOLS: LIST OF SPECIES FOUND.

Zoo Lake: 23 visits.

- Sida crystallina
- Daphnella brachyura
- Daphnia pulex
- Daphnia sp(?) (see notes)
- Simocephalus vetulus
- Scapholeberis mucronata
- Ceriodaphnia sp (?) (see notes)
- Bosmina longirostris
- Camptocercus rectirostris

Alona guttata
Alona testudinaria var. inermis
Pleuroxus denticulatus
Chydorus sphæricus

South Park Pond: 8 visits.
Daphnia pulex
Simocephalus vetulus
Bosmina longirostris
Macrothrix laticornis
Pleuroxus denticulatus
Chydorus sphaericus

Sixth Avenue Bridge Sloughs: 7 visits.
Daphnia pulex
Daphnia sp(?) (see notes)
Simocephalus vetulus
Scapholeberis mucronata
Ceriodaphnia sp (?) (see notes)
Pleuroxus procurvatus

Pools at Belt Line Bridge: 4 visits.
Daphnia pulex
Simocephalus vetulus

Flood Ponds at East Tenth and Vine Streets: 5 visits.
Sida crystallina
Daphnia pulex
Simocephalus vetulus
Moina paradoxa
Bosmina longirostris
Alona guttata

Forty-second Street sloughs: 3 visits.
Daphnia pulex
Simocephalus vetulus
Scapholeberis mucronata
Scapholeberis angulata
Ceriodaphnia sp (?) (see notes)
Lathonura rectirostris
Alonopsis latissimus
Alona guttata
Dunhevedia setiger

Nourse's Slough: 3 visits.
Daphnia pulex
Ceriodaphnia sp(?) (see notes)

Fortieth and Kingman: 1 visit.
Pleuroxus denticulatus
Camp Douglas Slough: 3 visits.
Daphnia pulex
Simocephalus vetulus
Zoo Pool: 9 visits.

This is a small pool cut off to the south of Zoo Lake very shady and a muddy bottom. Few hundred square feet in area. Not described above.

Findings
Sida crystallina
Daphnia pulex
Simocephalus vetulus
Moina paradoxa
Bosmina longirostris
Chydorus sphaericus
Dunhevedia setiger.

Some notes on unidentified species.

Daphnia sp (?) This is a form evidently belonging within the pulex group but resembling more or less the form described by Prof. Forbes of Illinois in his Yellowstone Park Report as *D. dentifera.* It has the same prominent two toothed angle on the dorsal outline between the heart and eye as described in *dentifera* but differs therefrom in having the spines well forward on the dorsal outline, a single process to close the brood chamber rather than two such processes and in having an accessory comb present while it is absent in *D. dentifera.* The form was found only in Zoo Lake and the Sixth avenue Bridge pools.

Ceriodaphnia sp (?) A form closely resembling *C. reticulata* but difering therefrom in having two long, jointed flagella rather than blunt ones at the junction of the post-abdomen and abdomen, process for closing the brood chamber absent or very obscure and seven rather than eight anal teeth. Found only at the Zoo, Sixth Ave., Forty-second street and Nourse Pond.

Total findings.

- Sida crystallina
- Daphnella brachyura
- Daphnia pulex
- Daphnia sp(?)
- Simocephalus vetulus
- Moina paradoxa
- Scapholeberis mucronata
- S. angulata
- Ceriodaphnia sp(?)
- Bosmina longirostris
- Camptocercus rectirostria
- Lathonura rectirostris
- Alonopsis latissimus
- Alona guttata
- A. testudinaria var. inermis
- Pleuroxus denticulatus
- P. procurvatus
- Macrothrix laticornis
- Chydorus sphaericus
- Dunhevedia setiger

This brings the list of Iowa cladocera up to 33 determined and 4 undetermined species reported to date, 23 determined and 2 undetermined having been reported in Vol. 3, and 6 determined species in Vool. 4 of the proceedings of the academy by L. S. Ross.

FOOD OF SUBTERRANEAN CRUSTACEA.

BY L. S. ROSS.

Supply of food and demand for it is one of the important factors to be considered in the struggle for existence, a factor that insistently demands proper attention on the part of every organism in its solution of the problem whether it shall exist or shall not. Many students have observed, many have killed and dissected hundreds and thousands of animals in determining what is the character of the food supplies of various species living in the water above ground, and on the surface of the earth, but not many it seems have entered seriously into the determination of the food of those living in the waters under the earth. We have a sufficiently satisfactory knowledge of at least a part of the food of the Chinch bug the Codling moth, and the Boll worm, but we know little about the food of the subterranean animals.

It is unnecessary to say that conditions in the darkness of the caverns and of the smaller underground cavities and channels are not favorable to the production of an abundant flora and that relatively only a small amount of fragmental vegetation may find its way into such channels from the surface of the ground. The original supply of animal food the plant, is then decidedly limited in quantity. The total food supply must come from the animals and plants living in the underground waters and from material both animal and plant that is washed in by the streams from the surface. In his classic publication, "The Cave Fauna of North America", Packard states that he observed four or five species of fungi in Mammoth Cave and also that another observer, Mr. Hovey mentions a few fungi from the same cave. In his discussion with reference to the food supply Packard says: "As to the food of the aquatic *Crangonyx* and the *Caecidotaea*, one would suppose it would be almost wholly animal, but unless they devour their own young it is a matter of conjecture how they can maintain an existence. Still more difficult is it to conjecture what forms the food of the young of these Crustacea since Infusoria, Rotifers, and Copepods are so very scarce. It goes without saying that there are no truly vegetable eating animals living pemanently in caves; no plant life exists (except in rare cases a very few fungi, and most of these probably carried in by man) in the caves on account of the total lack of light." Cope, referring to the Wyandotte cave fauna says: "As to the small Crustaceans little food is necessary to support their small economy, but even that little might be thought to be wanting, as we observe the clearness and limpidity of the water in which they dwell. Nevertheless the fact that some cave waters communicate with outside streams is a sufficient indication of the presence of vegetable life and

vegetable debris in variable quantities at different times. Minute fresh water algae no doubt occur there, the spores being brought in by external communication, while remains of larger forms, as confervae etc. would occur plentifully after floods."

In a very recent communication with reference to the feeding habits of cave Crustacca Prof. C. H. Eigenmann says: "I know that in our caves about here (Bloomington, Ind.) they depend on decaying vegetation carried into the caves. In Cuba they live directly and indirectly on the roots of trees growing on the margins of the caves."

In the summer of 1902 in company with Mr. R. E. Richardson of the Illinois State Laboratory of National History, I made a visit to a cave in Monroe Co., Ill. In the vicinity of the cave are many sink holes which probably have communication with the cave or with others near by. Oak leaves present in the small stream flowing through the cave indicate some of the openings for communication with the outer world are of relatively large size. In this cave numbers of individuals of *Gammarus fasciatus* were taken; an examination of the alimentary tracts of several specimens showed the presence of no other food than fragmentts of phaenogomous plants. In addition to the vegetable fragments there were grains of sand and some minute mineral crystals. A brief examination of the plankton of the cave by Mr. Richardson showed the presence of at least two species of Entomostraca, four species of Rotifera, two of Protozoa, four of Algae, besides quantities of vegetable debris. The collections were not taken with the idea, at the time, of making a quantitative examination so the amount of water passing through the bolting cloth was not measured. The estimations of the amount of plankton are not at all accurate but were made under rather than over the actual amount. A bottle of plankton was counted that was believed to represent the amount taken from about five liters of water but in making the estimate it was considered to represent the quantity from ten liters. The usual method of precipitation and counting the plankton was followed, and the estimate made for one cubic meter of water. The estimate is as follows:

Phaenogamous vegetable fragments, length 1000 microns, or more	3,960,000
Phaenogamous vegetable fragments, length 500-1000 microns	4,230,000
Phaenogamous vegetable fragments, length 100-500 microns	21,480,000
Phaenogamous epidermal hairs	1,470,000
root hairs	510,000
Algae, Cladophora fragments	60,000
Mesocarpus	30,000
Spore cases	30,000
Total vegetable	31,770,000
Protozoa, Arcella discoides	90,000
Rotifera, Brachionus angularis	90,000
Entomostraca, Cyclops fragments	30,000
Nauplii	120,000
Total animal	330,000
Total animal and plant	32,100,000

In addition to the material listed there were very many fragments of vegetation so minute no attempt was made to count them. The vegetable material was yet sufficiently preserved that the cells could be readily seen. By measurement the quantity of material removed from the water by the net was 154 C. C. per cubic meter. Of this 138.60 C. C. or 90 per cent was sand and clay leaving 15.40 C. C. or 10 per cent of organic material. This estimate is to be considered as very conservative for the reasons assigned previously.

The season up to that date June 20, 1902, had not been one of heavy rains to wash in large quantities of debris, but on the contrary had been one with moderate rains so that the quantity of vegetable material in the water of the cave at that date could not have been above an average for the summer season but was probably somewhat below it.

The *Gammarus fasciatus* found in the cave seem to be normal individuals of the species with the exception of the eyes in which an atrophy of the lens has begun although the optic lobes and nerves are yet well developed. These seem to be largely or wholly vegetable feeders living upon fragments of phaenogomous plants, and probably pass their existence in the darkness of the cave as evidenced by beginning atrophy of the eye. A few individuals of *Caecidotaca* were found also in the same cave.

Whatever may have been the food of the species from which *Crangonyx mucronatus* was derived it became necessary as the species found its way into subterranean channels for its food to be largely animal, or of vegetable debris. Some vegetation could be carried by the same stream that carried the crustacean but the vegetation could not accommodate itself to the changed conditions while the animal could. The crustacean would have a relatively limited supply of dead and decaying vegetable matter in addition to the other animal forms finding their way into underground channels. The food of *C. mucronatus* in those specimens examined consists of both animal and vegetable tissues, the animal supply predominating and consisting largely of *Cyclops*. Examination of a few freshly caught specimens from a well showed the following food materials had been taken.

Vegetable, Algae, *Drapernaldia*, *Gleocapsa*, *Oscillaria*:

Vegetable, Phaenerograms; fragments, and plant hairs.

Animal, Earthworm fragments as indicated by setæ, *Rotifer* eggs fragments of unknown Entomostraca, fragments of *Cyclops*.

Specimens in an aquarium were observed seizing upon a dead *Asellus* and devouring considerable quantities.

Plankton examinations of the wells show that only very limited quantities of vegetation are available as a food supply. It is upon the animal life then that the species must largely depend for its supply, and this is of necessity limited in quantity. As a result of such a limitation a change in the number of young produced as well as in the size of the eggs has been brought about. There is not sufficient food for a large number of individuals and the struggle between these individuals is

probably as severe as that between the surface forms. The number of eggs carried by one female taken June 3, 1902, was five; by another taken in July the same year was six, and by yet another very large specimen taken in the same month the number was ten; measurement showed the eggs to be large, .54 m. m. A *C. gracilis* carrying eggs was examined and the number found was twenty while the diameter was not much over half that of the eggs of *C. mucronatus*. The young of the one are produced where there is a goodly supply of food near at hand, and the other where considerable search may be necessary before any be found. The one has a limited supply in the egg, the other, *C. mucronatus*, has a more abundant supply. Packard has noted the small number and large size of the eggs in the cave spider, *Anthrobia*, and Smith refers to the fact "large size and small number of the eggs is a very marked characteristic of many deep sea Decapoda."

From the statement quoted from Prof. Eigenmann and from the observations recorded in this paper it seems we may conclude that vegetation eating animals may find sufficient food in subterranean waters for the sustenance of a limited number of individuals. In some waters however as in many wells, the amount of vegetable life or of debris is very small; under such conditions the individual crustacea whether feeding upon vegetable or animal tissues must be few.

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PLATE I.

Fig. 1, Lower figure. Camera end of telescope with eye piece attached.
Fig. 7, Upper figure. Gibbous phase of moon

Photograph by D W. Morehouse.

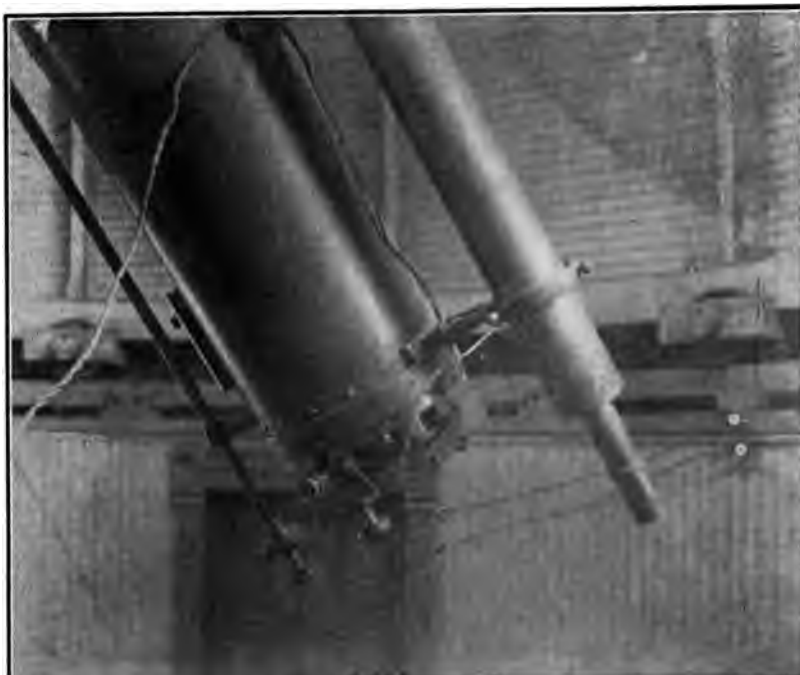
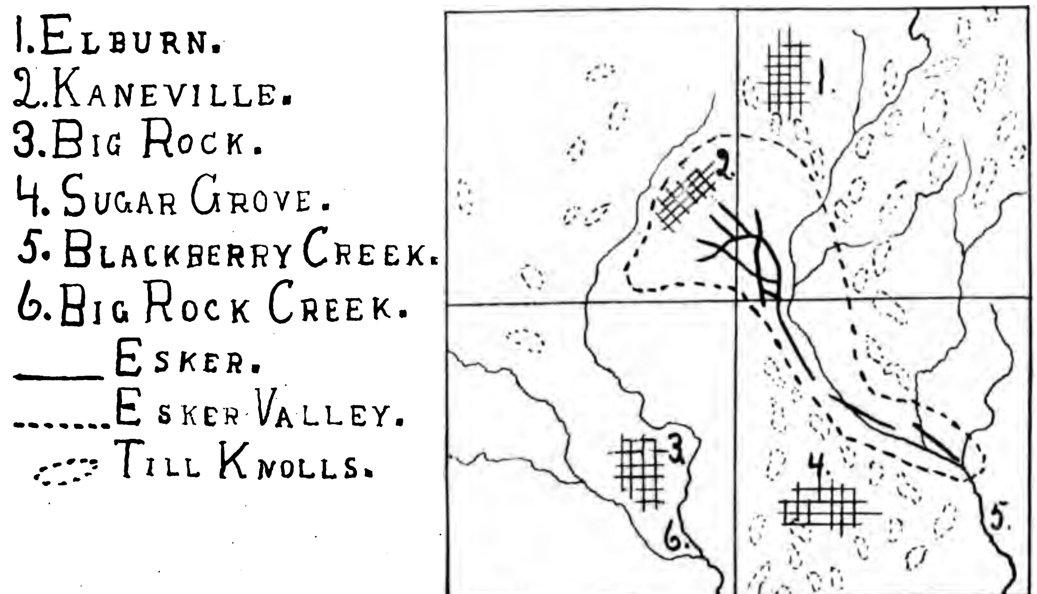


Fig. 2, Upper figure Camera end of Drake telescope in position.

Fig. 3, Lower figure. Observer at work.

PLATE III.

Fig. 5, Upper figure. Double star Cluster in Perseus.
Fig. 6, Middle figure. Crescent moon.
Fig. 4, Lower figure. Great Nebula in Orion.
Photograph by D. W. Morehouse.



Map of the esker, the esker valley and delta, and the surrounding region.

Fig. 1 Rounded hill at Clarence Humiston place, from north west, showing xerophytic top; less xerophytic toward base; blue vervain conspicuous.

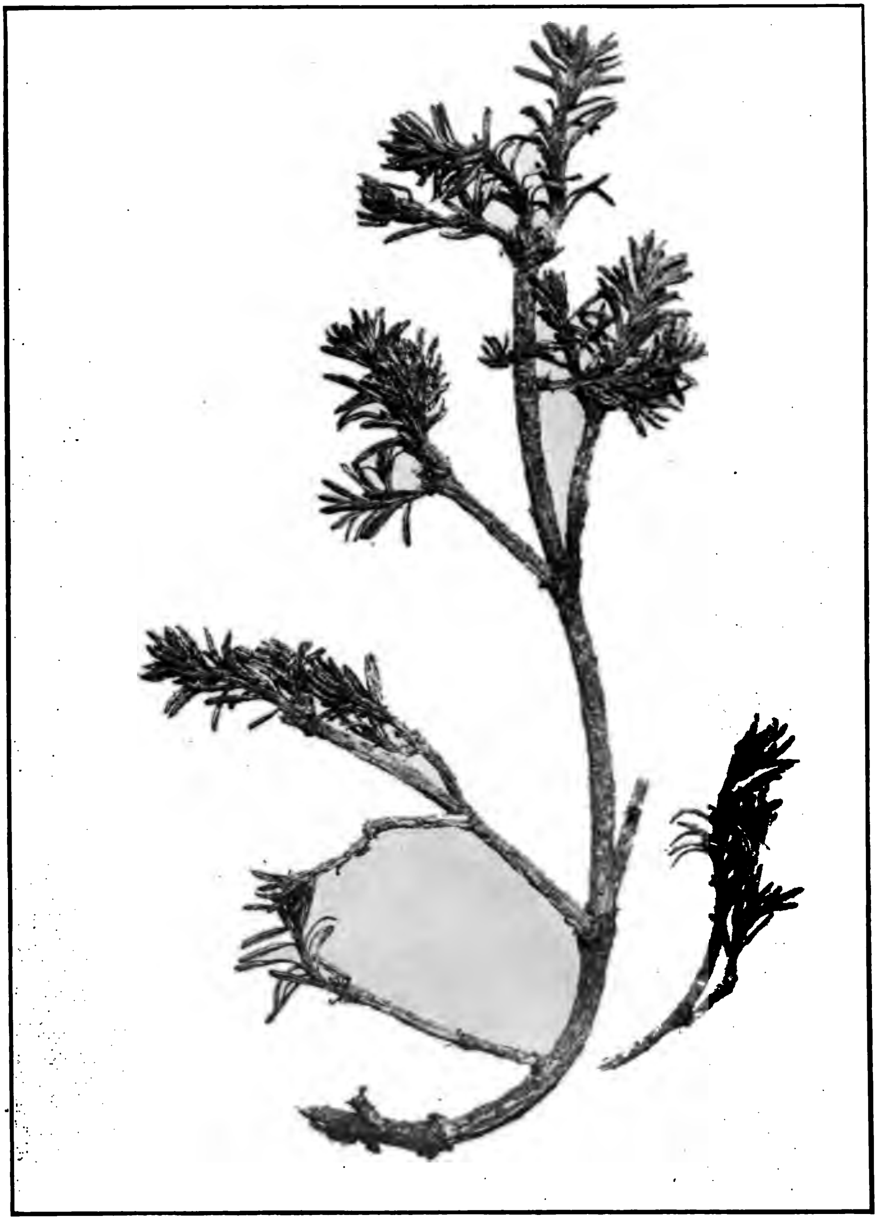
Fig. 3. Crown of Johnson's Mound showing small portion of xerophytic strip and the border of the mesophytic area on either side.

PLATE VI.

Fig. 2. Portion of the esker directly back of the Dorr yard, showing the less xerophytic conditions at the base of the south side, the more xerophytic south slope and narrow regular crown, and trees of the north slope showing above the crown.

PLATE VII.

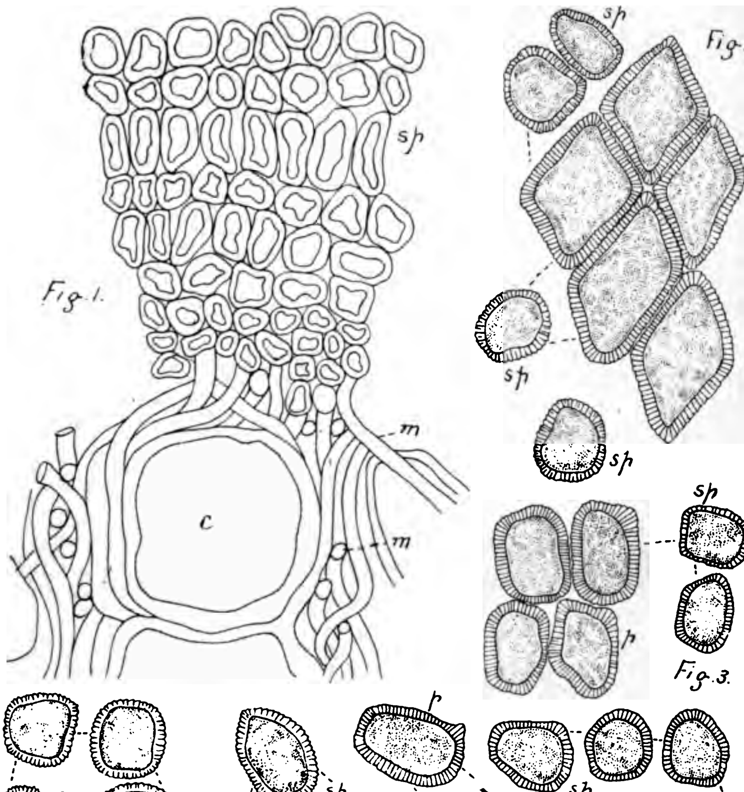
Figs. 1 and 2. *Peridermium cerebrum* **on Lodge Pole pine. (Fig. 1, longitudinal section of branch.) (Fig. 2, view showing sori broken open exposing spores.)**
Fig. 3. *Peridermium elatinum* **on** *Abies subalpina.* **Photograph by Charlotte M. King.**



Peridermium elatinum on *Abies subalpina.*

Photograph by Charlotte M. King.

PLATE IX.



Figs. 1 and 5. ***Peridermium cerebrum*** **on Lodge Pole pine (*Pinus murrayana.*)**

Fig. 2. ***P. abietinum.***

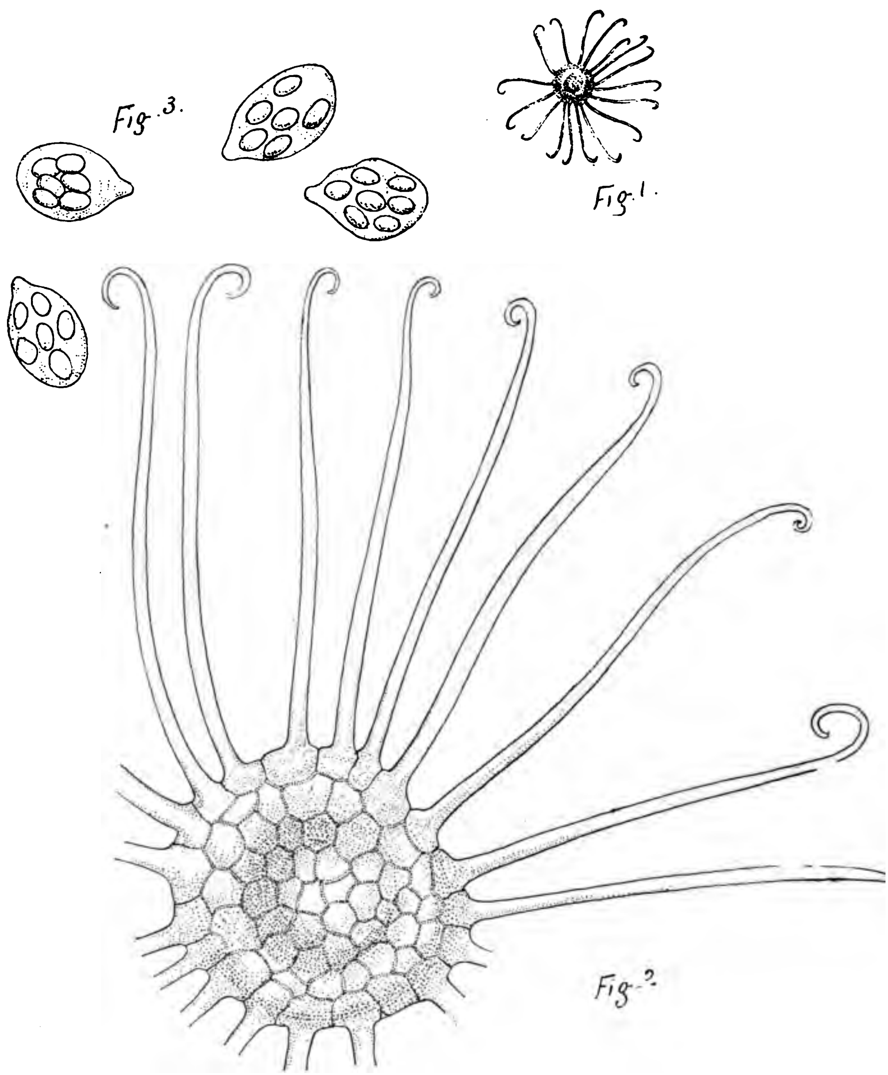
Figs. 3 and 4. ***P elatinum*** **on *Abies subalpina.***

Fig. 6. ***Peridermium*** **on *Picea engelmannii.***

sp-spores; m- mycelium; c-cavity of tracheid; p-peridial cells.

L. H. Pammel and Charlotte M. King.

PLATE X.



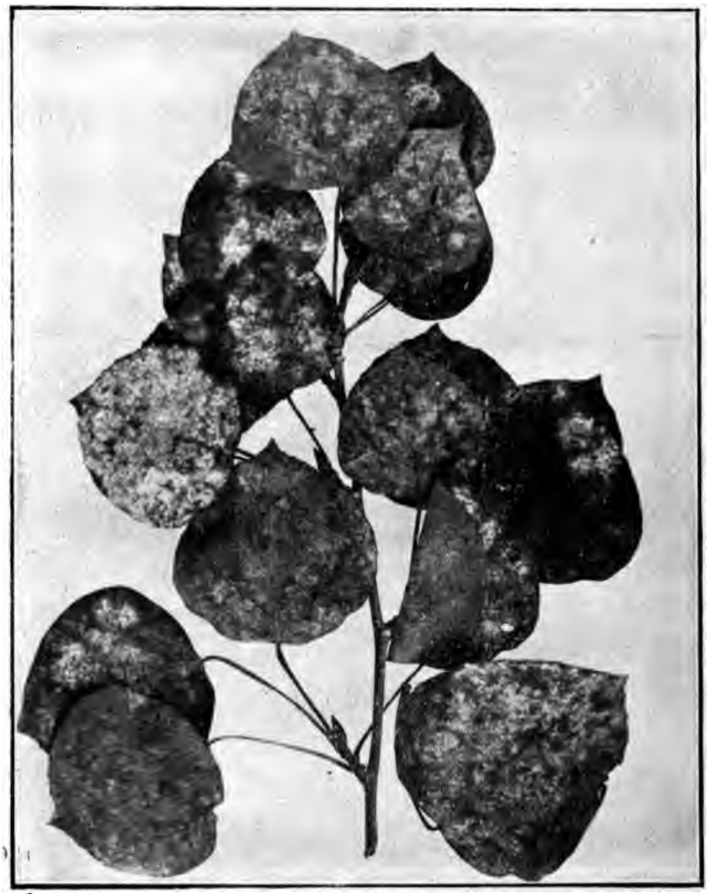
Uncinula salicis on *Populus tremuloides*.

Fig. 1. Perithecium and appendages. Fig. 2, more highly magnified.

Fig 3. Asci and ascospores.

Charlotte M. Kin

PLATE XI.



Uncinula salicis on Populus tremuloides.

Photograph by Charlotte M. King.

PLATE XII.

PLATE XIII.

"Spanish moss" in bayou near Welsh, La. Scene in Jan. 1894.

PLATE XIV.

Position of the Corinth Canal, Greece

PLATE XV.

Portion of Corinth Canal from Athens and Corinth R. R. bgride.

A piece of apparatus with which to illustrate tides and tidal action.

Plate XVII.

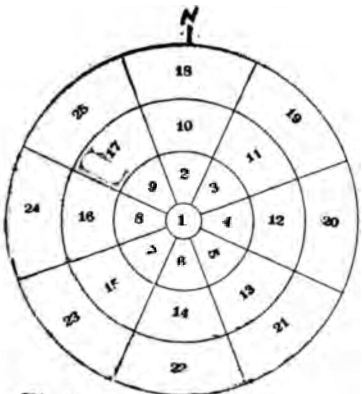


Fig. 1.

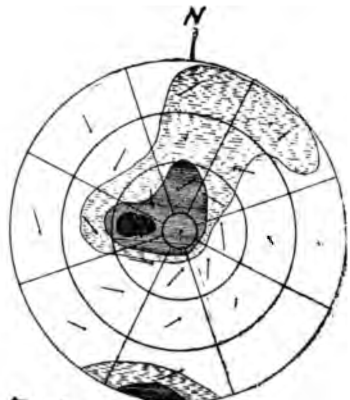
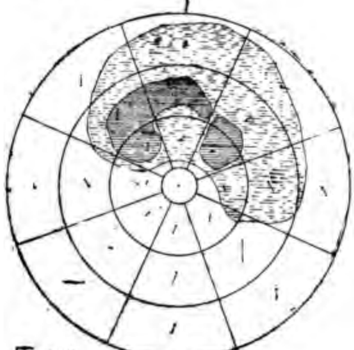


Fig. 2.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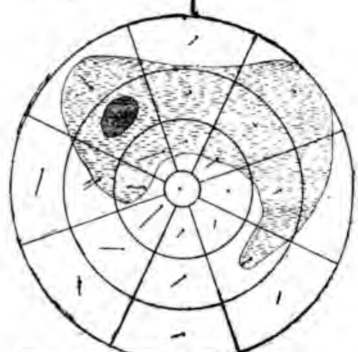


Fig. 4.

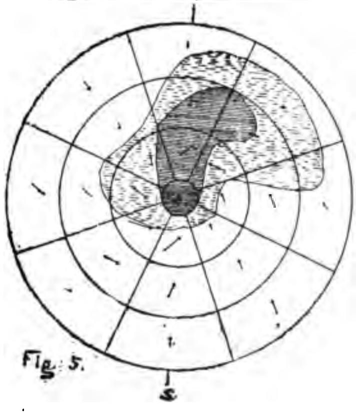


Fig. 5.

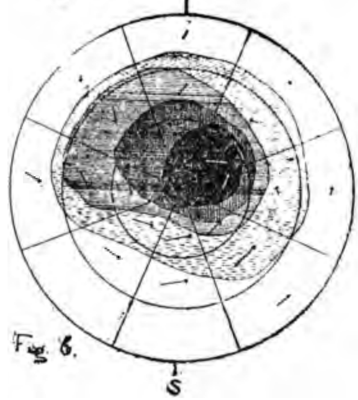
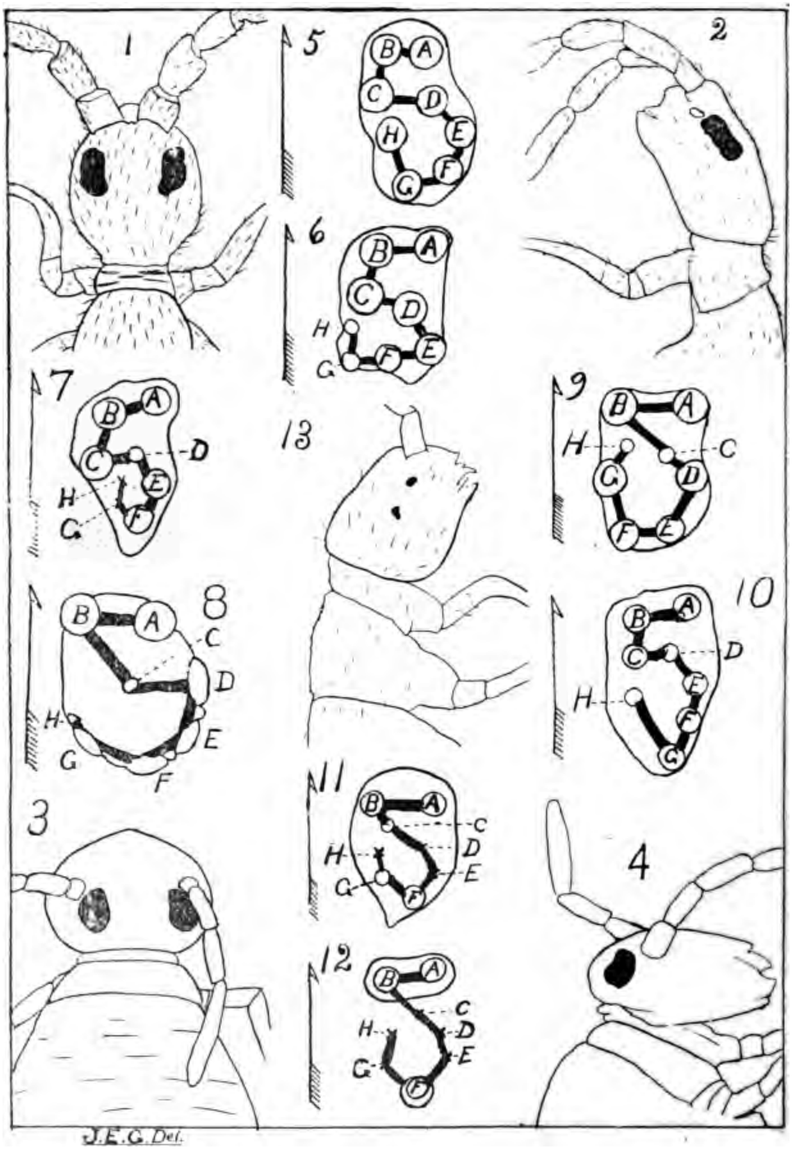


Fig. 6.

PLATE XVIII.



Collembolan Eye.

PLATE XIX.

Case 1. Nine months old.

Case 1 Fifteen months old.

Sporadic Cretinism.

PLATE XX.

Case 1. Three years old.

Case 1. Seven years old.

Sporadic Cretinism.

Case 1. Seventeen years old.

Case 1. Nine years old; sister six years and brothers three and four years

Sporadic Cretinism.

Case 1 Front view. Case 1. Side view.

Twenty years and four months of age at beginning of thyroid treatment.

Sporadic Cretinism

PLATE XXIII.

Case 1. After thirteen weeks treatment.

Case 1. After twenty weeks treatment.

Sporadic Cretinism.

Case 1. Twenty years and ten months old. Height increased two inches in six months of treatment. Taller sister seventeen years old.

Case 1. After nine months treatment.

Sporadic Cretinism.

PLATE XXV.

Case 1. After fourteen months treatment.

Case 1. After twenty-seven months treatment.

Sporadic Cretinism.

PLATE XXVI.

Case 2. Six years old; brothers four and seven years. Case 2. Eight years old; at beginning of thyroid treatment.

Sporadic Cretinism.